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THE ROYAL ENGINEERS JOURNAL

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Editorial

WHEN THINGS GO WRONG!

WHEN things go wrong, and they quite often do, reactions vary. Some bemoan their luck, some curse, some sit tight and hope the problem will go away, some just give in and accept the "inevitable", some break under the strain, some rise to the challenge and overcome misfortune.

In his article, "Plymouth Towards Newport USA", Mike Best describes his attempt to sail across the Atlantic single-handed. He did not make it and to him this was failure. But was it? He learned a lot, about sailing, about himself and about survival. All who read his article will react in some way. My first reactions were predictable. I can see nothing in sailing, there are quicker, easier, cheaper and more comfortable ways to cross the Atlantic! My later reactions were more complex and were tinged with admiration and envy. I think it was his acceptance of the challenge, his ability to cope when things went wrong, his approach to the solution and his assessment of the courses open to him which appealed to me. I felt that I had gained something from the account. Your reactions may be entirely different.

When things go wrong!

There can be little doubt that experience conditions the reactions to misfortune. The cliche, there is no substitute for experience, is true *to some extent*, though of little comfort to younger Members. Why the qualification "to some extent"? Because in this sense experience generally means *practical* experience and in my view *theoretical* experience can be of considerable value.

If this is accepted how can theoretical experiences be acquired by military engineers and in particular by the younger ones? The answer—*during training*. At all levels there are Schemes, Exercises, Exercises without Troops or their equivalents. Occasionally a spanner is thrown into the works; "The Divisional Commander has decided that he wants that mule track improved to a Class 60 road by tomorrow morning"; "The Armoured Brigade which was to support your attack has been delayed for twelve hours", these minor irritations are meat and drink to Directing Staffs! But not to worry—as events unfold luck changes (DS are always fair!)—the exercise is successfully concluded in time for a gin before lunch! If only real life were like that!

There is, in my view, a real need for imaginative exercises which are *designed to go wrong* in which the *real* Aim is to give the participants experience in coping with adversity. The *stated* Aims of such exercises are quite immaterial provided the *real* Aim is achieved. Unfair! Maybe—but is it not even more unfair to throw people into the deep end of life convinced that they can swim because they have been taught how not to sink? It is the pinpricks of life, often coming one on top of the other, which are the most common, the water trailer breaking down, communications failing, rain, 20lb of 4in nails being issued in lieu of 10lb of 8in, bridging lorries arriving at site in the wrong order—the list is endless. Coping with this type of problem is seldom built into either practical or theoretical exercises.

Such exercises would make the participants think, would develop flexibility, condition them to expect the unexpected and make them better military engineers. It is during these exercises, particularly during early training, that pressures should be applied, when the completion of the bridge, the breaching of the minefield or the repair of the runway is of secondary importance, it is what has been learned that matters.

Those taking part in such exercises may not enjoy the experience, the Directing Staff will certainly find it difficult to maintain realism and pace, but the experience gained will stand all in good stead later, when things go wrong.

Centenary Meeting of the Institution of Royal Engineers

ARTICLES AND CORRESPONDENCE INSPIRED BY THE MEETING

Captain J R Reid, RE, B Sc, C Eng, MICE
Civil Engineering School
Royal School of Military Engineering
Chatham
Kent ME4 4UG

CENTENARY MEETING—REINFORCED EARTH

Sir,—With reference to the letter in the *Journal* of September 1976, the following points may be of interest.

The subject of reinforced earth has been and is taught on Long Civil Engineer Professional Training courses. Two students, Captains Bray and Foster have written papers on the civil applications of reinforced earth. An Assistant Instructor in the Civil Engineering School, Captain Bennett has written a brief paper on the use of available membrane materials for building reinforced earth bridge abutments. The membranes may not be the most suitable materials. At present a statement of the requirement for reinforced earth structures is being sought, so that trials with a variety of materials and methods can be started.

Although this effort is not perhaps as good as the attentions of an officer with a spare year, the subject is not being forgotten.—Yours faithfully, J R Reid.

C A Stephens, B Sc(Eng), DLC(Hons) Eng, C Eng, MICE, MIWES
Public Works Department
Lautoka
Fiji

CENTENARY MEETING—ARE YOU A ROYAL ENGINEER?

Sir,—So,—you are an officer in the Corps of Royal Engineers (practising) and have just attained a professional qualification. Firstly, which professional qualification? There are a lot of them around and a fair sprinkling in the Corps. For my purposes I shall assume that you have got MICE. How did you get there? A degree course somewhere and then a Long Civil Engineering Course with (hopefully) an attachment for a longish period (over 1 year) to a major Civil Engineer project. The Institution Rules are such that provided you can persuade the Interviewers that you know what you are talking about you will probably become MICE.

What Civil Engineering do you do after that? Probably not much—you will be busy trying to get up the promotion ladder and getting a Staff qualification at the same time.

The question therefore is "Are you a Professional Engineer?"

In my opinion the difference between the Sapper officer and the civilian can be summed up in two words—money and experience.

The civilian nearly always has to prove that a certain course of action is the most economic; the RE doesn't have to worry about cost. The civilian is in Civil Engineering all the time; the RE for perhaps three or four years. The civilian has to think of all the possible ways of doing a job; the RE perhaps only has to decide which text-book approach is the most suitable, probably a "Meccano" set.

I am not saying that the RE is a dullard but that he does not have the contact or necessity to do out-of-the-ordinary things in peacetime. In wartime the situation is

different and "Necessity is the Mother of Invention". I would hope that Sapper officers have the necessary inventiveness but I would suspect that this is not so, broadly speaking. I would hazard a guess that in wartime the officers who do the *Engineering* are mostly conscripted civilians while the "regulars" are promoted to positions of high authority and do not have the same necessity to make instant decisions.

Anyone reading this who thinks I am just a civilian may be pleased to know that I have been a Sapper (am still a Sapper?) who would much rather be in civilian life. My experience of Sapper life was small (about four years), but very little engineering other than from the textbooks was ever carried out and I would guess that the majority of Sapper officers never learn much about engineering away from the textbooks.—Yours faithfully, C A Stephens.

Bridging Equipments for the 1980/90s

MAJOR J N BARNIKEL, M Sc, C Eng, MIMechE

Commissioned into the Corps in 1940 following training at RMA, Woolwich and 141 OCTU, Major Barnikel served with 4(Br) Div and 56 Div in Algeria, Tunisia and Italy before being wounded on a river crossing operation. He obtained his degree in engineering at RMCS, Shrivenham as a student on No 1 (Backlog) YO course and stayed on to take his M Sc for postgraduate research. Posted to MEXE, now MVEE (Christchurch), in 1950 he retired from the Army in 1954 and joined the Scientific Civil Service, remaining on the staff of the Establishment. He has worked on bridging, field defences and water supply projects and, as a Principal Scientific Officer, was leader of the International Concept Study Team referred to in this article.

INTRODUCTION

THE British Army is equipped with very high performance bridging equipments which have recently come, or are now coming into service. The Chieftain Bridgelayer with its No 8 (80ft—24·4m) and No 9 (44ft—13·4m) Tank Bridge covers the Assault Role. The Medium Girder Bridge, with piers and span junction sets, provides an excellent Dry Support Role capability while the Amphibious Bridging and Ferrying Equipment M2 enables large rivers and canals to be crossed speedily in the Wet Support Role. However, these equipments will not last for ever and, furthermore, it is anticipated that by the late 1980s there will be a need for higher mobility, improved obstacle crossing capabilities and faster construction and retrieval, using less manpower; so, new equipments will be required.

It was agreed at the second meeting of the Quadripartite Working Group on Bridging and Gap-Crossing Equipment in 1969 that research studies should be initiated with the aim of generating concepts for the next generation of bridging. It was further agreed that collaboration between nations was highly desirable as this might eventually lead to joint development and production with the potential advantages of reduced national costs, the elimination of duplicated effort and better prospects of standardization within NATO. In June 1970, following the issue of invitations to potentially interested nations, a meeting was held in the UK which was attended by delegates from the ABCA Armies and the Federal Republic of Germany. As a result, the United States, the Federal Republic of Germany and the United Kingdom agreed to form an International Concept Study Team (ICST) at the Military Vehicles and Engineering Establishment (Christchurch) (MVEE(C)). Operational requirement staffs met in November 1970 and produced an agreed Operational Requirements Guidance Document; subsequently a Memorandum of Understanding was negotiated and the two documents formed the charter for the ICST which assembled during the Summer of 1971 and reported to national authori-

ties in May 1974. The Team was monitored and directed throughout by an International Technical Steering Committee, which met at six monthly intervals.

OPERATIONAL REQUIREMENTS GUIDANCE

Outline requirements given to the ICST were as follows:—

Assault Role

Spans:	essential, 20m—with a short span capability up to 12m. desirable, 30m
Launch time:	5min (max)
Recovery time:	10min (max)
Crew protection:	as main battle tank

Dry Support Role

Spans:	essential, 40m clear span—but capable of being used at shorter spans.
Construction time:	40m span in 15min by day or night; longer bridges to be constructed in compatible times.
Recovery times:	40m bridge in 30min.

Wet support Role

Timing:	Construct a 120m bridge, cross a battle group of 150 vehicles, dismantle and disperse the bridge to a distance of 4km—all in 1 hour.
Bridges/Ferries:	Essential, construction of the equipment in either bridge or ferry configuration.

General Requirements

Support role mobility:	to accompany the forces being supported.
Commonality:	maximum commonality of components for all roles.
Manpower:	significant reduction in manpower for operation, maintenance and storage.

ICST PROGRAMME OF WORK

The ICST terms of reference called, initially, for a very broadly based approach and so early tasks were studies of the state of the art of military bridging, worldwide, and then the generation of ideas, however far fetched, for appraisal. Among well over 100 concepts, hover devices, freezing, boiling and in-situ foaming all received attention. The Team rapidly came to the conclusion that the evolution of well established principles offered the only prospects of success within the specified time frame.

Concepts were outlined by the Team and these were the subjects of paper studies undertaken by firms and the Bridging Branch at MVEE(C). Meanwhile, the ICST performed a number of practical trials and experiments to demonstrate the feasibility of selected aspects of the concepts and to produce data.

In parallel with the main line of work on concepts, several other supplementary studies were undertaken as essential parts of the programme. The most important of these were:—

(a) *The Definition of Parameters for Design.* This dealt with such widely ranging items as limiting weights and dimensions for ease of movement by land, sea and air—acceptable slopes for bridge access ramps and the required capabilities of ground-bearing piers.

(b) *Obstacle Statistics in Relation to the Required Bridge System Performance.* In this study a bank of obstacle data which had been collected in the Federal Republic of Germany was compared with systems of dry and wet bridges, having graded crossing capabilities. In this way it was possible to establish the minimum performance required from the elements of the system to ensure a crossing at all reasonable sites.

(c) *Materials.* This involved a comprehensive review of the characteristics of structural materials and their practicable fabrication methods and covered both well

proven and new developments. A practical extension to this study involved weapon firings at samples of materials to determine their response to ballistic attack—some, otherwise promising materials, shattered.

(d) *Assessment of Effectiveness and Life Costs.* The Team was charged with demonstrating that it had selected the best concept and that this was an improvement on the current bridge systems of the participating nations. This exercise provided some of the most knotty problems encountered by the ICST because of wide divergences of opinion on the importance to be attached to the various elements of effectiveness and because of difficulties in calculating all the expenditures which contribute to life cost.

(e) *Trilateral Design Code for Military Bridges.* The preparation of this document was an essential pre-requisite to international collaboration. It was produced by independent groups, working in parallel with the Team.

The last six months were spent in the collection and collation of information, in evolving the preferred concept and in writing and publishing the Final Report (in both English and German). The Report runs to ten volumes and weighs eleven kilos!

THE CONCEPT

A gratifying outcome of the ICST Study was the unanimous agreement of the Team on the choice of concept. There were, within that concept, differences of opinion on details of the proposed design which reflected personal and national experiences and preferences. The Team did not have the time or the resources to carry out the necessary studies for final selections to be made and these open questions were left to be answered during later phases of development.

In developing and selecting its preferred concept the Team was strongly influenced, among others, by three very significant considerations:—

First. The importance of transporter/launcher vehicles for the Assault and Support Roles, capable of carrying long lengths of pre-assembled bridge, of connecting them rapidly on site and of speedily launching the whole, as means of achieving the very limited construction and dismantling timings, and the required manpower economies.

Second. The need to provide the Support Role transporter/launcher vehicle with a high standard of mobility; better than that of the logistic trucks now used.

Third. The very real advantages to be gained from commonality both of the bridge structure and the launching system for all roles, advantages in versatility and adaptability to meet tactical and geographical situations expeditiously, and in reduced quantities of equipment to provide a given bridging capability.

It is now possible to examine the proposed bridge system, bearing in mind the foregoing factors, but it is not the intention, in this article, to go into great detail nor to describe all the variants, as many changes are bound to be made following further studies. It is only desirable at this early stage to present the reader with broad outlines (Photo 1).

BRIDGE STRUCTURES

Fig 1 shows the common structural components, used for all roles. The girder system is in the form of a double trackway with a centre gap because this configuration can best accommodate the types of launching gear which can readily be fitted to bridgelaying vehicles; filler panels can be inserted in the gap when a full width deck is required in the Support Role.

The 6–8m long centre and ramp panels in aluminium alloy minimize the cost and weight of joints and have sufficient strength to span 27–30m for MLC 60 traffic. Half panels can be used on those occasions when the accurate tailoring of bridge spans to gaps proves necessary. Actual panel lengths will be selected at a later stage when requirements and practical constraints are finally established.

An alternative variant envisages the use of girder panels of triangular cross section which could be lighter and less bulky. However, it remains to be demonstrated that a satisfactory launching system can be devised to be compatible with this

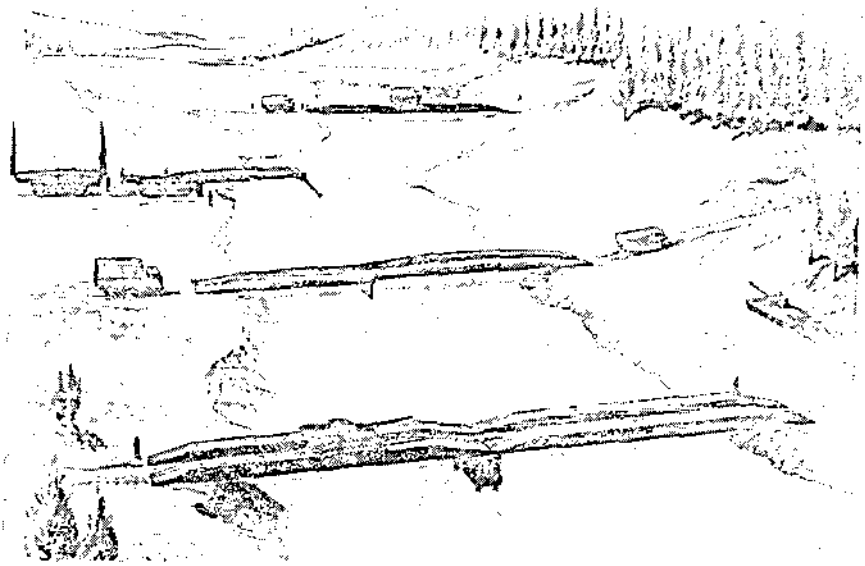


Photo 1. Artists Impression of the ICST Concept.

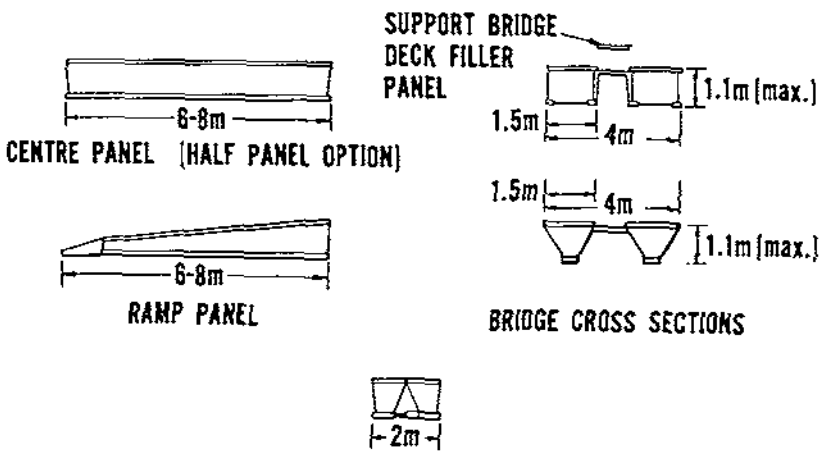


Fig 1. Common Structural Components.

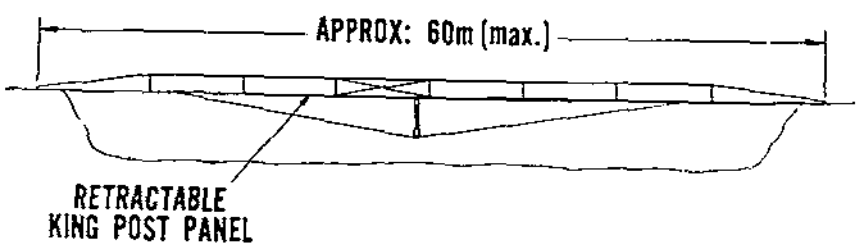


Fig 2. Girder Reinforcement Kit.

are folded back for travel and swung out in line with the girder and locked prior to launching.

(b) The "sliding" system, a development of that used on the Biber AVLB (FRG), in which the two halves of the bridge are carried one above the other and are manoeuvred horizontally into alignment for launching.

WHEELED TRANSPORTER/LAUNCHER VEHICLES

Fig 4 illustrates the highly mobile wheeled transporter/launcher vehicles which the ICST proposed for the Support Roles. The Team considered that up to 30m bridges might be carried and launched (with the aid of a launching nose to compensate for limited counterweight) by a single vehicle. Longer bridges would be carried in sections on two or three vehicles. A 40m bridge could be transported on two vehicles for subsequent connection and launching over the first vehicle. In this way only one joint would have to be made on site and a fifteen minute construction time was considered to be feasible with a team of six to eight men, despite the use of the reinforcement kit (Photo 2). In one variant of the concept vehicles other than the actual launcher are fitted with handling davits which lift and manoeuvre their bridge sections into alignment for the joint to be made, irrespective of ground irregularities.

FLOATING BRIDGES AND FERRIES

For the wet support bridge and for ferries, two solutions were offered by the Team. Both fit into the family concept as they are based on the dry bridge girder and are transported and launched by the wheeled launcher.

DISCRETE FLOTATION SCHEME

In the discrete flotation scheme, buoyancy is provided by large powered pontoon piers of about 40 tonne capacity, possibly having the same cross-section as the girders. The pontoons are launched in a controlled manner by means of the standard

Photo 2. Wheeled Transporters Connecting two long bridge sections for launching.

Bridging Equiptments for the 1980-90's.

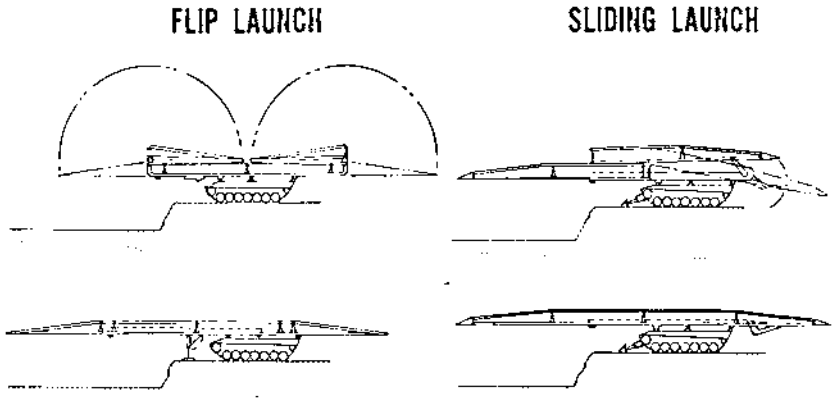


Fig 3. Assault Bridgelayers.

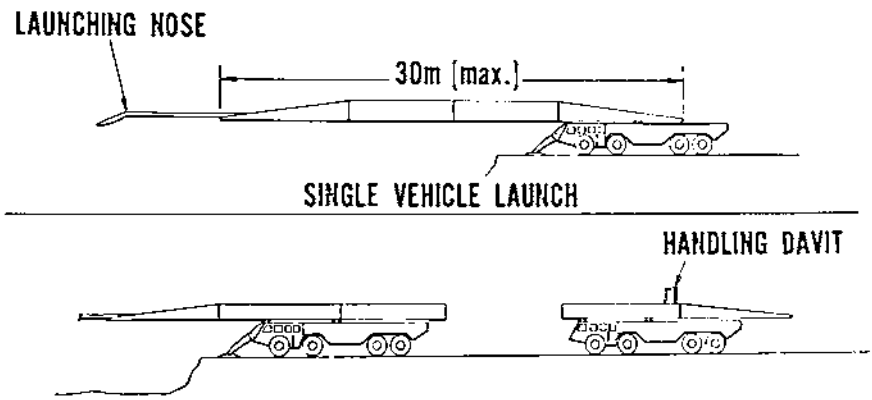


Fig 4. Support Role Launchers.

girder form and, more particularly, the trapezoidal cross-section transitions which occur along the ramp taper (the straight bottom chords of a rectangular girder form a good interface between launcher and bridge).

The articulator panel is used for adjusting the ramps of floating bridges and for multi-span dry bridge constructions.

GIRDER REINFORCEMENT

The ICST foresaw a need to be able to reinforce the basic girder to increase its span capabilities and proposed a king post girder reinforcement kit (Fig 2).

The principle is that a special panel, but otherwise compatible with standard panels, is fitted into each girder; a pivoted king post is housed inside the panel for transport and launching, and, after the bridge is launched, it is swung down and the cables are tensioned. Triangular girders can be similarly reinforced but stowage restrictions lead to a less elegant solution.

ASSAULT BRIDGELAYERS

For the Assault Role, the ICST favoured horizontal launching methods to achieve a low silhouette and for compatibility with support bridges which are most easily emplaced by this method. Two options were offered by the Team (Fig 3):—

(a) The "flip" or "folding ramp" system, in which the ramp ends of the bridge

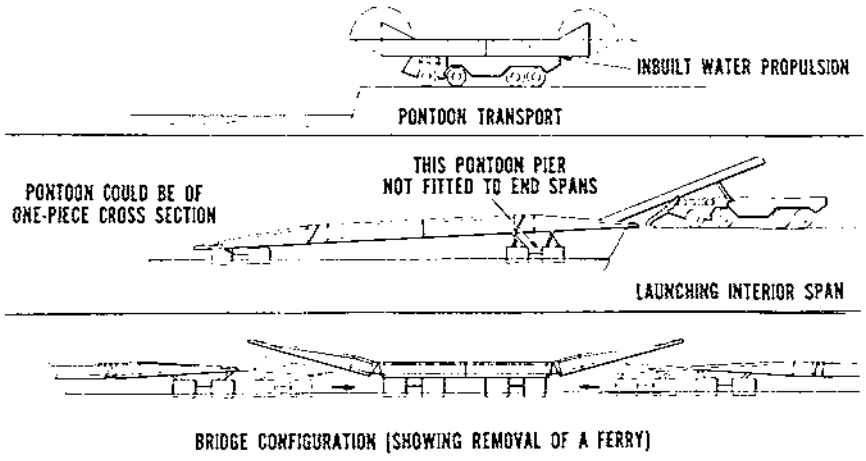


Fig 5. Discrete Flotation Scheme.

launching gear. In another variant, two pontoons are carried on each vehicle and are launched in sequence. The bridge is made up of relatively few long spans (with length adjustment by removing panels). Ramp articulators can be fitted if adjustments are required to produce a flat deck or if ferries may be needed. Features of the scheme are:—

(a) the single, easy to make, above water joint between spans.

(b) the good reach of the landing bay and its ability to cope with a high bank.

(c) direct breakdown of the bridge into ferries.

CONTINUOUS FLOTATION SCHEME

The continuous flotation scheme is a development of the well known Ribbon Bridge. The dry bridge structure is made buoyant by adding a centre folding section, pneumatic bags inside the girders and bow pontoons. Improvements on existing Ribbon Bridges arise from the fact that :—

(a) the vehicle drives straight to the river bank and launches over its front end, so saving time.

(b) each vehicle carries and launches twice the current length of bridge—about 14m. Comparing the two systems, it is possible to say that:—

(a) *The Discrete System* is based on long established principles and involves virtually no special features added to the dry bridge girders. What we do not know is whether it will achieve regularly the required timings under all conditions of wind and current.

(b) *The Continuous System* seeks to improve on relatively new principles. Extremely fast building times have been achieved because the pontoon sections open

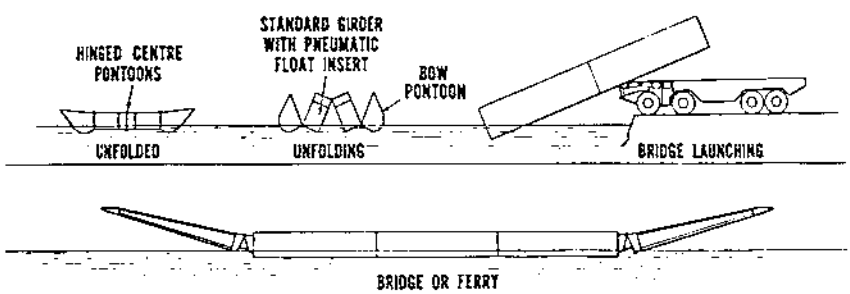
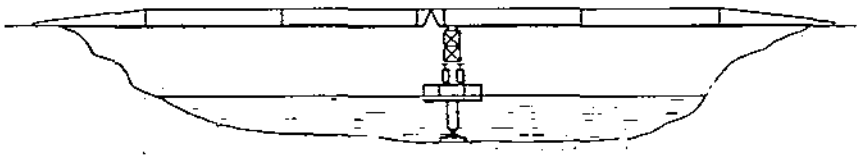
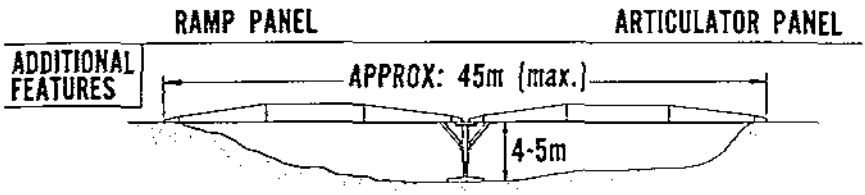


Fig 6. Continuous Flotation Scheme.



MOBILE PIER
(EMPLACED BY AMPHIBIOUS VEHICLE)



ASSAULT PIER

Fig 7. Ground Bearing Piers.

automatically in the water and, once connected, are ready for use because their decking and stiffening girders are integral. The doubt is whether it is possible to make an effective floating bridge by adding buoyancy elements to the basic girder.

GROUND BEARING PIERS

The ICST foresaw the need for ground bearing piers to make multi-span dry bridges in both the Assault and Dry Support Roles (Fig 7).

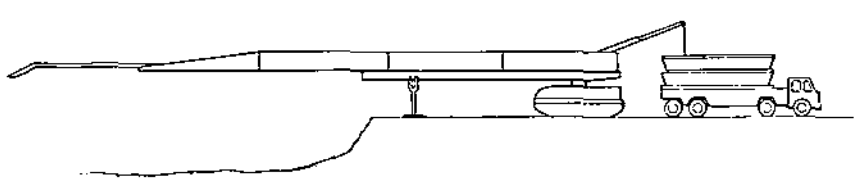
The Assault Bridge Pier (which is launched with the Assault Bridge) enables multiple span bridges to be constructed under near-assault conditions; "near-assault" because some exposure of men would be necessary to adjust pier legs before use and in the event of sinkage after trafficking. For two spans the obstacle crossing capability would be in excess of 40m, with a maximum pier height of 4–5m.

A Mobile Amphibious Pier for the Dry Support Role permits ground bearing piers to be constructed in parallel with bridge construction and, hence, saves time.

MECHANICALLY AIDED HAND CONSTRUCTION

The ICST considered that a true hand erection capability for Dry Support Bridges would be incompatible with the time and manpower savings demanded. However, it was possible to propose a lower cost construction system than the wheeled launcher by means of a mobile Launching Platform (Fig 8).

*The platform is a semi-trailer towed by any suitable vehicle (eg APC) via a fifth-*wheel attachment. It carries part of the bridge pre-assembled. On arrival at the site the trailer wheels (not shown in Fig 8) are retracted and firm supports are lowered and levelled—the vehicle supports the other end of the platform and also provides



LAUNCHING PLATFORM (50m max.)

Fig 8. Launching Platform (maximum bridge length 50m).

counterweight. A jib raises girder elements from trucks for attachment and the bridge is boomed forward so that succeeding panels can be added. Using the method illustrated, a 40m bridge could be built by twelve men in 30-40 minutes which, although not meeting the guidelines, provides a useful facility for Rear Area or air transported operations.

CONCLUSIONS

The ICST Study left a number of options open and many questions regarding feasibility unanswered. The collaborating nations are now engaged in a work programme involving paper studies, mock-ups and practical trials in the hope that an agreed best solution may emerge. The original Memorandum of Understanding has been extended to cover this so-called Interim Phase until the Autumn of 1978. The longer term aim is co-operative development and production.

The First Six Months of World War I (Concluded) Spring 1915

The end of the First Battle of Ypres, 21 November 1914, was described in Part 5. There is a gap in the diary and quite obviously the author has stopped his daily detailed entries. He admits to the device "enlarged as memory allowed in November 1918." The style has therefore changed but to maintain the sense of time the Editor has added the dates where they can be deduced.

In this, the last of the extracts, the author covers 27 March 1915 to 18 April 1915, a day marked by the capture of Hill 60. (It was finally lost on 5 May 1915). This is the period covered in Corps History, Volume 5, pp 217–218.

PERSONAL NOTES JOTTED DOWN BY THE WAYSIDE (PART 6)

K B GODSELL, 17 FIELD COMPANY

March 25th, 1915.

In the shuffle of units that took place early in 1915 we found ourselves transferred from the 5th to the 27th Division. It was on 25th March that we received orders to leave our comfortable billets, desert our peaceful occupation of defending the slopes of MEMMEL and proceed to YPRES. Although nothing had been heard of this city since November last, those memories were still fresh and it was with a foreboding of evil times that we set our faces to the North.

ST ELOI, one of the heels of the salient had been very noisy only a fortnight ago, and two of our subalterns had been lent to Territorial Field Companies to give them the benefit of their winter's experience. These Officers did not give a good account of the health of this neighbourhood: we felt we were descending into the crater of a volcano, and so we were.

It was a bright and gusty morning when we started off, in buses, and proceeded to YPRES. We were ordered to billet in the station, which looked all right on the map. The buses took us via BAILLEUL and CAESTRE and landed us in YPRES at 9.0 pm. One of the buses broke its axle so we had to leave it behind: the Peacock was left in charge and came along later in a new bus. The transport took a shorter route and arrived just after 4.0 pm. The station, like most other stations, in its balmy days must have been very cold and draughty; it had been heavily shelled during the six weeks of 1st YPRES, and had since received its daily dose, so every bit of glass, of which there was much, was broken. The floors were concrete, the doors were smashed and the fireplaces quite inadequate. It was quickly decided that the situation was impossible, and as higher authority would not look after us, we decided to billet ourselves. The officers reconnoitred the district and good billets were easily found close by. The men were put into the first floor of a large warehouse; it had a

sound roof and a wooden floor, and straw being procured locally the men were made very comfortable. The wagons and horses were put into another warehouse next door with the drivers sleeping overhead. The officers went into two cottages on *the other side of the road, the cottages were furnished but deserted, and were being* looked after by a neighbour who was quite indignant when we said we were going to live there, and we had great difficulty in getting the key. By evening everyone had found a corner either for his office or his bed, his meals or his ablutions. The usual squabbles took place and acrimonious remarks passed between sections over their billets, no one being quite satisfied that the other had not rather "done him".

Very little time was given for settling in, as soon as we had had a meal, the Major took Willie and myself out to reconnoitre the work which had to be commenced that night—hence the bus ride. We went down the LILLE railway until we struck the YPRES—NEUVE EGLISE road. The line to be constructed ran roughly parallel to this road. We sent our guides back to bring the sections up to the level crossing as soon as it was dark, while we went out and decided the details of the work.

The line of the trench was marked out with a few pegs: the difficulty was to find any ground where it would be possible to dig without coming to any water. The Major decided to make a breastwork in the wet ground, and a semi-breastwork where possible.

The sections arrived just after dark and stores were brought out on the pontoon wagons which had been unloaded of the bridging materials. The night was quiet and good progress made. Each section put up some 200 yards of revetment. We got back to billets about 4.0 am. Squabbles were forgotten and the stars shone out over a contented and snoring unit. The volcano was inactive.

March 26th 1915.

After a good night's rest we got up at 10.0 am and Willie and I took a walk into YPRES. The weather was delightful, very bright and sunny with a spring snap in the air. YPRES gave us a most pleasant surprise, for instead of charred ruins, we found a prosperous town. There were unmistakable signs of the ordeal it had gone through which became more evident as one approached the "Grand Place". The Cloth Hall and Cathedral were both badly knocked about but their shape and outline were not seriously damaged. It was easy to see where the 18" shells had pitched, for where they fell nothing was left except an enormous hole or levelled ruins on either side. The most extraordinary example was the big hotel opposite the station which had been hit bang in the middle by one of these shells, a large triangular chunk had been removed from the building, comprising at the top almost the entire roof, and diminishing to a 30 foot wide hole in the basement. We wandered through the town visiting the places of interest, and carrying away small pieces from such places as the Cloth Hall and the Cathedral as souvenirs, coloured glass, plaster, bits of wood. The *streets were full of all sorts of people, soldiers, Belgian, French and English, civilians* from the fashionably dressed to the vendors of sweets, flowers and vegetables. The Grand Place was a busy scene, streets barrows stood all round it and all over it. With difficulty the heavy Army transport made its way through the cosmopolitan throng. The air was full of the foreign jabber, the cries of the stall holders and the shrieks and yells of the legion of children who gambolled up and down, and in and out. The Grand Place was the epitome of life, the life of a prosperous community. *Yet, within 3 miles lay Death; Death in all its most violent forms, organized slaughter* on a scale hitherto unknown to men. While YPRES carried on its money-making careless life, forgetful of its recent lesson, thousands of hungry, greedy, vicious eyes squinted longingly at it from the surrounding hills and waited for "Der Tag" when they would march in triumph through its reeking streets. Once as we stood there a shrapnel burst high over the Cathedral, men jerked a thumb at it and jeered, while here and there a woman shuddered visibly, and then the sales continued. A Taube came over and received a welcome from the Archies, the little puffs of smoke looked delightful against the clear sky, but the aeroplane silver in the sunlight, save for its black crosses, continued in its flight until it disappeared a speck in the avikite. A few

looked up and shook their fists and muttered curses, some gazed with fear until it passed from view, but most gave it a casual glance and continued with the business of the day. We wandered on and found a café where we had some light refreshment served by a dainty fairy, then having visited a photo shop and bought some interesting photographs and made other purchases of interest only to the Mess Members, we returned to our billets.

After lunch the necessary preparations were made for the night's work, and the rest of the afternoon we rested. The sections paraded at 6 pm and proceeded to the work. Two territorial battalions at full strength, the Argyle and Sutherlands, and the Royal Scots, reported for work and were employed in throwing up earth against the wire netting revetment put up the previous night. They were fresh troops and full of zeal, in consequence rapid progress was made. The difficulty was to get them to dig far enough away from the wire netting. After working for some time several of them had to be moved away and fill up the hole they had just made before the breastwork could be thickened. The infantry came in two reliefs of four hours each, and it was with difficulty that the revetting party was able to keep ahead of the diggers.

March 28th 1915.

For the next few days our programme was unaltered, out all night, sleep till ten, go for walk, and off again to the job at 6 pm. I had many strolls round YPRES and got to know all the best places. Food stuffs for the Mess were easily procurable but were expensive. During these days we lived in greater luxury than ever before.

Our walk round the ramparts was particularly interesting. I saw the old causeway where the Company got stuck when marching in in October, 1914. In daylight it looked a most difficult place to turn a company round, so how it was done in the dark without putting a wagon or two in the moat I don't know. It was impossible to wander round such a neighbourhood in such apparent safety on glorious spring days without getting bitten with the craze for souvenirs. For the first time since the War began one could think in comfort, and know more or less for certain that you would be able to take a night's rest without fear of unpleasant disturbances. Suddenly wandering in the scarred fields round YPRES the craze bit you, you saw a shell fuse and picked it up, before you knew what had happened your pockets bulged with bits of shell, cartridges, cartridge cases, bombs, bits of rifles, and oddments of all sorts. You had become a confirmed souvenir hunter, a sympathizer with the silver spoon maniac. It was then the search really began which gave such additional impetus to these strolls. Willie was a past master in the art, the Peacock and I but clumsy novices, but even we got some interesting things which were duly consigned home, and gave great joy.

At dusk on the fifth day the Bosch shelled our billets, I don't think he meant to, he was making a boss shot for the road junction close to the Asylum. One shell dropped in the courtyard of the warehouse, and wounded a RAMC Orderly attached to the Company, and took the seat out of one of the drivers trousers—he was wearing them at the time. When we went up to work that same evening, we had to wait for half an hour as the cottages along the NEUVE EGLISE road were being shelled by some heavy stuff. The Bosch made rather a mess of them and set one on fire. The inhabitants, who were still living in them, were naturally terrified and had to clear out. They came back later during the night, and removed their valuables and disappeared, cursing everybody German, English, French and Belgian. It was very pathetic to see the old people leaving their home without a hope in the world. The infantry working-party had a bad night too; one party dug up a very dead calf, and another party an old horse.

The breastwork, by now, was connected on the right to a similar work constructed by the Division on the right, so we started extending it northwards on the other side of the canal towards ZILLEBEKE. After everyone had got going well with the work, the Peacock came up to me with a mysterious load under his arm. I was then let into the secret; he had found an unexploded shrapnel shell the night before, and proposed with the assistance of a detonator and primer to blow the head off, and salve the

shrapnel bullets and the fuze. We dug a little hole, fixed the charge, and fired it. Unfortunately the shrapnel turned out to be high explosive, and all that we could find after a loud explosion was a big hole but no shell.

The weather continued brilliantly fine but very cold, especially at night. There was a bright moon which was a great asset towards progress on the works. When we arrived back at our billets in the early hours of the morning we always had a cup of hot cocoa which warmed and refreshed, and was not uncomfortable to sleep on.

April 2nd, 1915.

On April 2nd the rumours lately current, that we were going into the line east of YPRES gained ground. As it turned out that night was the last night we spent on our rear line. We had quite enjoyed the nine days work, for it was such a change to have fresh troops to deal with whose strength had not been sapped by exposure and discomfort and weeks of nerve racking trench warfare.

During the night's work I was walking along with the Major when we came to a road on the right of our line running down a beautiful avenue. We were exploring the chateau at the end of the avenue when we were suddenly set upon by two burly beings, who subsequently turned out to be Gunners. The chateau was our Gunner HQ and the Major knew the OC RA well so we were released and suspicion removed. The "White Chateau" was in full view of this chateau and was the Bosch Gunner HQ so each could retaliate when their HQs were shelled. The Bosch however was beginning to find out that his guns were more numerous and much more powerful than ours and he had given the HQ an awful pounding all the afternoon.

April 3rd, 1915.

On the 3rd the Major and the senior subaltern visited the front line which we were about to take over, and reported the trenches deep, dry and wide, with bad wire and poor parapets.

We spent Saturday in resting and refitting preparatory to going up to advanced billets. Our Infantry working-party was withdrawn to undergo further training in a back area and the line was handed over to another Field Company.

Civilians were noticed leaving YPRES with their household goods. There seemed apprehension as to what the Spring might bring forth, but save for the fact that we were often shelled at night, the volcano remained inactive. For the next few days little happened. The line was not taken over as originally arranged, but Willie with No 3 Section went up on the 5th and took over from the French Engineers. Our Infantry took over the line the following day.

In the meantime the Company was rested and a little training, indulged in. It was the first opportunity we had had of doing anything of the sort since arriving in France last August. The day was started with a little drill and followed by demolition practise, fixing and firing of charges. There was an iron road bridge over the canal quite close to the billet which each section in turn prepared for demolition. Another morning was spent in a route march along the canal north of YPRES. The temporary bridges over this canal were all inspected on the way as far as POESINGHE and the NCOs required a make a report on any two of them. The bridges had all been constructed by the French and varied in size and description. The barrel-pier bridges appeared rather "Jerry-built", but they had stood the wear very well and were still used. All of the bridges were carefully marked according to their strength, some being for Infantry only, some for horse transport, and some for heavy guns. One very neat one for heavy guns was built on two barges, one barge submerged lengthwise and the other floating at right-angles to the bridge. There was a high bank on the east side of the canal so that the bridges were covered from view. Some of them could only be used at night as the bank was exposed on the enemy's side. We were told the Bosch was very fond of putting shrapnel over during the night, to try and catch the traffic but for the most part his shooting was too high. It was a beautiful day when we went up and the canal looked very inviting and cool running along between two rows of tall poplars. Whenever we halted at a bridge the men had great talks with the French guard. As neither spoke the others language these conversations were very

comical consisting of a flourish of hand on the one side, and "oui! oui!" on the other.

In the afternoons the men were left to themselves and the officers passed the time in letter writing and exploring the district. The Germans continued to drop shells round about during the night but were making better shooting and most of the shells were going well over. One afternoon we tested the penetration of a bullet from a service rifle and got the most amazing results. We found one sandbag of broken bricks was sufficient to stop a bullet. As this differed so much from the Manual we scratched our heads and discovered the difference was due to the fact that we were firing at about 20 yards range which did not give the bullet time to steady itself after leaving the muzzle, and hence it hit the sandbag on the wobble and lost most of its penetrating powers. There is no doubt that this fact has been the cause of a lot of the reports about the enemy using explosive bullets.

April 7th, 1915.

On the 7th the Major took me up to the line to see Willie and have a look around. It was a very quiet and fine afternoon and we rode up as far as BELLEWARDE FARM where we left the horses. We had to go by a cross-country track as no traffic was allowed on the MENIN ROAD in daylight beyond the level crossing. As YPRES was left behind the country became more and more battle worn and scarred. Every field had its quota of large shell holes, and almost every house had been hit; the road was strewn with trenches and pitted with patched up holes. From BELLEWARDE FARM we had quite a long walk to the front line, and passed through the village of WEST HOEK on the way.

The ground was drying fast so that the going was good and the country had an air of Spring about it. The trees were beginning to bud, and in spite of high explosive all nature was blooming forth into life. Even the shell shattered stumps were making an effort to show that the Hun was really not such a fearful fellow. At WEST HOEK we were actually on the ground where that famous fight took place in November, 1914. NONNEBOSCHEN WOOD was within a stone's throw. All round here during that fateful day the fight had waged with varying fortunes until rallying with a super-human effort our troops drove the Bosch back to the top of the hill and over the crest. There he remained and there he was now. The trench dug was still our front line, and graves and corpses along it marked the Bosch's furthest point.

BELLEWARDE LAKE was about the centre of the battery area and as we passed up we saw several batteries of field guns cunningly concealed in hedges and the forward edges of the woods. We also saw several abandoned positions, obvious in their neglect. The reason for the vacant pits was not far to see; a broken wheel, a mass of shell holes, bits of equipment, perhaps a dead horse, and the tale of a few hours strafing was told. Men and horses may have died, or been wounded, deeds of heroism may have been done, a detail in the picture, "on our left flank there is nothing new".

From YPRES TO BELLEWARDE is a gradual slope up, WEST HOEK is almost the same level as BELLEWARDE with a small ridge or underfeature between, from WEST HOEK the ground rises sharply to a long ridge on the top of which lies POLYGON WOOD and ZONNEBEKE.

We met Willie just on the far side of WEST HOEK, as usual on the scrounge. He had four heavily laden Sappers with him, who were carrying loads of timber and planking collected from some ruins in WEST HOEK. He was full of buck and as happy as a king. The trenches, it appeared, were in a fair state and, joy of joys, could be reached in daylight. Ideas on trenches change as women's fashions. All through the winter we had been working on the line which faced MESSINES. This line ran half way down a forward slope with the Hun sitting on top of the opposite hill. Attempts were made to construct a communication trench to the front line, but lack of stores and the impossibility of the nature of the soil prevented it. The result was that the front line was isolated all day and could only be reached at night, so that if it was necessary to reconnoitre a proposed job in daylight as it often was, we had to remain

in the front line all day, which wasted a lot of time and made it impossible to make any preliminary preparations during the day. The winter of 1914 was very wet and those who have never seen the trench system of those days find it difficult to believe the conditions under which the line was held and maintained.

The three essential difficulties were the soil, materials and labour. Once I was given the job of making a dug-out near NEUVE EGLISE for the GOC. We dug a hole 7 feet deep and 18 feet square, and arranged for drains to carry away the water.

Tree trunks were put in to carry the roof, and by nightfall all of them were in position and fastened by battens to keep them secure for the night. The next morning on arrival at the job, to our dismay, we saw that a portion of one side had fallen in. The bottom of a big chunk of clay had slipped inwards carrying with it four tree trunks. Henceforth each morning to a greater or less extent the same thing happened. Finally we fixed up a solid box built round the tree trunks, and filled in against the sides, and all seemed as good as could be. We were soon thinking of how we could ornament the place and make it look nice! Alas our work was in vain for it was discovered that as the side could not now fall in, the floor was rising! The clay was pushing itself up and filling in the hole. A dug-out of this type, a cut and cover type, would be nearly as practical in treacle as in this soil.

With nothing except wire netting and green pickets trenchwork in such soil was impossible. If a trench was dug and left unrevetted, at the first rainfall the whole hillside slipped and blocked up the trench. There was no way to clear it out! It was thick and sticky and would not leave the shovel. It was in such stuff that men stuck and could not be removed; they remained and died. The only labour was drawn from the Supports and Reserves; the men were exhausted by sleepless nights in the line, and worn out by continual exposure and a succession of trench duties and fatigues: they were out at rest for two nights, one of which was spent in marching four miles up to the line again for work, being shelled on the way up and down, and sniped at all the time they were working; probably getting wet through and as often as not getting lost and wandering for miles. Under such conditions the task of getting a job of work done was well nigh heartbreaking.

Things seemed very quiet, occasionally a whizz bang came over and now and then a sniper sniped. The line was approached through POLYGON WOOD and we called at a battalion HQ on the way up. After visiting the line and having a quick look round, we returned by the way we came. The pressing need of the moment appeared to be good communication trenches into the front line and some form of support trench at present non-existent. I did not see Willie alone so the impression gained was distinctly pleasant and a great improvement on what we had left behind.

April 9th, 1915.

On April 9th I took my section up to the line and joined Willie. We paraded at 1045 and arrived at our destination without incident. Willie sent a guide to meet me at the cross roads at WEST HOEK who conducted us to our billets. The two sections were accommodated in some roughly constructed huts on the western edge of POLYGON WOOD. The huts had been constructed by the French who, I afterwards learned, had been shelled out of them. They were made out of the small fir trees of which POLYGON WOOD chiefly consisted; the tree trunks, 3″ to 6″ diameter, were laid at about 45 degrees on to a centre horizontal ridge piece with their butts on the ground. They had then been roughly covered with tarred felt with a little earth thrown on top; the floor was sunk some 18 inches. They were weather-proof if little else, and comfortable and warm. When the men had their fires going at night it looked far more like a picturesque gipsy encampment than a precarious abode within three hundred yards of the front line. I left the section to get settled in and have a cold meal, for fires were not allowed in the daytime, while I went down and joined Willie at the cottage. Now the cottage was one of Willie's masterpieces, of which he was justly proud. At the bottom of the valley just behind POLYGON WOOD ran a small road which connected the MENIN road to the WESTROOSEBEKE road, running nearly north and south. Along this road, dotted about were several

cottages and small farm houses, several of which were still occupied by their owners. One of these lying on the direct route of POLYGON WOOD had suffered severely and was deserted. Willie had taken over this place, and by means of doors and windows salved from the deserted WEST HOEK, and by filling up the holes in the walls by sods, had made a most comfortable and commodious billet. Being at the bottom of the valley it was possible to cook at all hours and my section were delighted at being able to wash down their meal of bully and biscuits with hot tea. In the cottage there was the kitchen where both sections did their cooking, which included the officers, and also two small rooms, one used as a bedroom, the other for meals. The other room on the ground floor was used by the NCOs, a proportion of whom were allowed to sleep there, the remainder sleeping up in the WOOD with their sections. The first floor, or loft, was too rickety to be of any use. As an RE officer was required day and night, it was arranged that one of us should do day duty and the other night, changing each night. The officer on night duty slept at the cottage, the other sleeping in a hut near the sections. The NCOs and men for the most part worked at night, and slept in the daytime.

Having spent some time admiring Willie's handiwork, we then settled down to the real business, and had a jolly good lunch which I much appreciated after the march up. During our meal Willie, with the assistance of an indifferent map, explained the situation. The main work on hand was the construction of communication trenches on the right and left of our sector, the former outside the wood, and the latter inside. A support line was also being made half in and half outside the wood. The wood only covered two-thirds of the sector.

After lunch we went round the line and found everyone very happy. The front line was connected throughout and could be reached in two places. On the right one had to be careful as the CT was as yet very shallow, and the German line easily visible on standing up. There were several quaint niches and shelters in little trenches behind the fire trench where the garrison slept when off duty. The French had a good idea of comfort, but I don't think they did very much firing as the parapet was very thin on the top. The wire was also indifferent and it was difficult to repair as the Hun was so close. On the left there were three inclined galleries some 25 feet long at the end of which two sappers were posted to listen in case the Bosch was mining. The French had left a rumour that this part of our trench was mined, but we were never able to confirm it. We did not like the French for this rumour as it gave us a lot of trouble and the Infantry much unnecessary anxiety.

On the whole the front line was satisfactory and required no further work than the garrison could do for themselves except where a loophole was required here and there. When our Infantry took over the line there was a lot of sniping but it all came from one side, a condition of affairs they quickly set to work to remedy, but it took some time before we got any ascendency.

On our return we had tea in the Cottage and as Willie took the night work I slept in the huts in the wood. I was up early the next morning, being awakened by the Bosch shelling a ruined shed towards the left of the wood—a favourite target of their's for some unknown reason—as no one ever went near the place. As it seemed very quiet I went for a stroll over the ground behind the wood. The old battlefield had never been cleared properly, the ground being strewn with remnants. Nose caps by the dozen, rifles of various nationality, ammunition, cartridge cases, equipment, all lying about, some in good condition, some rotting from exposure to the weather. In NONNEBOSCHEN WOOD there were several German corpses still unburied, lying where they had fallen. Care had to be exercised in picking up such things as boots, for as often as not there was a foot inside. I came across one curiosity; a shell from a field gun had hit a small tree and after penetrating nine inches had got stuck without exploding. There were a number of unexploded shells of all sizes lying about, Napoleon-like, they had missed their destiny, probably due to Herr Schmidt, who had not set their fuses right.

After a meal at 7.0 am I took the parties up to work, including the reliefs for the

listeners; I also inspected the loop-holes that had been put in during the night; six were put in, but only two were serviceable, the others either pointed into the heavens or looked straight down into the ground. It was very difficult in the dark to place the loop-holes correctly. The type used was the box loop-hole, steel loop-hole plates not being available, which are long, and if not accurately placed are useless. They were put right that night, the NCO responsible for them having had a good look at them before dark. One portion of the trench was very wet due to a surface spring and it could only be kept dry by baling and pumping. We had to pump the water over the parapet towards the Bosch. It was found that the pumps were making no headway and then it was discovered that the water was coming back through our own parapet as fast as it could be pumped out. The repair of pumps was an unending job: they were flimsy things and did not respond to the heavy handed caresses of the British Tommy. The trench was always kept useable, but you had to step with care as now and then the trench board over the sump hole started floating and the unwary took it well above the middle. The soil was chiefly sandy with a certain amount of clay and loam. It was surprising to find in the middle of the wood a swamp with over a foot of standing water, but Belgian soil is full of surprises.

After completing my rounds which included visits to the Bn HQ to fix up the details for the night's work I returned to the cottage. Willie had just got one eye open, the threat of a cold sponge quickly revived the other. He had had a quiet night, and had made good progress, but there were several nights work ahead before any practical results could be expected. The rations the preceding evening had brought several rumours and one piece of information. The rear billets had been shelled, another of the shells had gone into my room and wrecked it making a terrible mess of all the kit I had left behind; one of the shells dropped among the drivers killing one and wounding three others.

April 11th, 1915.

On the 11th, "Tubby", another Special Reserve Officer, relieved Willie and the same procedure and work was carried on. On the night of the 12th the Bosch dropped shells much too close to our huts to be pleasant but did no damage. I fancy his aeroplanes, which are very active in the early morning before ours got up, must have spotted that the huts had been re-occupied. It was a great satisfaction being able to look at the night's work the next morning and see what had been done: the men were also pleased for after a hard night's work there was no miserable muddy trek for 3 miles back to billet. Ten minutes from the job and they were home.

April 13th, 1915.

On the 13th I was relieved by the Peacock and took my section back for four days rest. The best of good things pall and although everyone enjoyed their tour in the line, comparatively speaking, all looked forward to their four days behind. After the experience of the other night and in order to save transport going through YPRES, the CO decided to move the rear billets to the other side of YPRES and accordingly they were now in the process of being established just outwide POTIJZE. YPRES was becoming a bad place at night, especially the "Gates", and the MENIN GATE in particular. The whole length of the MENIN ROAD, the main artery and communication to the front line, was sprinkled with shrapnel every night.

At 8.0 am next morning, after a good night, I paraded with my section and proceeded to the 2nd Line to work on the trenches. This line had been commenced by the French and ran roughly parallel to the present front line. It ran about 300 yards in front of BELLEWARDE WOOD, thence outside WEST HOEK, enclosing the high ground, to the POULERS–YPRES railway. The Line consisted of lengths of trench, front line only, which were well wired by a continuous belt of wire. We were employed in joining up the lengths of trench, putting in Machine Gun Emplacements, and digging support trenches. The disadvantage of this line will be seen later: it was never used. While we were working, the Bosch started shelling so we had to lie doggo till he finished. He was really trying to get a battery of field guns that were in position 200 yards behind where we were working.

We knocked off for an hour in the middle of the day and as there was no shelling going on I went over and spoke to a Gunner subaltern. He complained very much of the rotten shells the Bosch was using which smelt horribly and made all their eyes water. One of his men was so bad he had to be sent back. He was also full of grouses about the Bosch aeroplanes which appeared to have their own way, and were not interfered with either by our planes or anti-aircraft guns. I had certainly seen five of them overhead all the morning and nobody attempted to interfere with them.

The following day we again worked on the 2nd Line and had a most exciting day. Wherever we went we were shelled. We did not suffer any casualties, but the shells were dropping much too close. In one case a big shell dropped on the parapet of the trench we were taking shelter in. It blew in the parapet and made us all in a beastly mess. The Taubes were again much in evidence and the Bosch had an observation balloon up, but it seemed too far off to see a handful of men as we were. One Taube was brought down, much to our delight. Both the anti-aircraft gunners and the Machine Gunners claimed this bird. To us it mattered not who hit it so long as it came down. As soon as the "Archies" opened fire the Taubes retired to the neighbourhood of their own lines and thenceforward we had a more peaceful morning. The smoke from the HE shells was most unpleasant, had a sickly odour and made the eyes run. On the way home the 'strafe" broke out afresh and we had to take cover in the bed of a stream. While we waited there, two shells fell in the middle of the lake with a harmless but most picturesque effect, a column of spray being shot up well above the highest of the trees. On arriving back in camp, we learnt there was a terrific scare on, the Bosch was going to attack with asphyxiating gas. The men had to sleep ready to turn out at a moments notice and the horses were harnessed all night, and the wagons loaded ready to move. We passed a peaceful night, and laughed in the morning. There was no doubt the volcano was rumbling.

April 16th, 1915.

The 16th was spent in rest and preparations for another tour in the line. During the morning the carpenters of the section were busy making the wood-work for a battery of six rifles. There was still considerable wind blowing about over the asphyxiating gas attack and the horses again went to bed in their clothes. We were told a delightful story of a large pipe being seen running from MENIN to the front line, and at the MENIN end, it was reported, was the gas factory.

April 17th, 1915.

On the 17th, I took my section up to the forward billets and relieved the "Peacock" and his section. The journey was completed without incident. I found Willie at the cottage, and after we had had lunch we went out to site the rifle battery. These batteries, which are really only glorified rifle rests, are firmly fixed pointing in the desired direction, and the rifles laid in them. The range of the target is then taken off the map, in this case a cross-roads, 1,000 yards behind the enemy's front line, and the necessary elevation put on the rifles. The rifles can then be fired periodically, either by a patrol or a sentry put there for the purpose. We placed our battery just below the crest behind Black Watch Corner, taking care to clear the crest by sufficient space to allow a man to walk on the top with safety. While still so engaged, the "Skipper" came along and we learnt that we were making an attack on Hill 60 that night to be preceded by the explosion of a large mine. In consequence, as the Hun was expected to retaliate by a heavy bombardment all along the line, night work was to be reduced to essentials and most of our working parties were greatly reduced. Willie took the night work so I turned in at the Huts, not without misgivings that I might shortly be turned out and rather roughly.

April 18th, 1915.

With the information of the coming attack on Hill 60, it was somewhat disconcerting to be aroused from torpor at 8.0 am by a violent bombarding, and heavy musketry fire on the left. Everyone seemed on edge, and the roll of the musketry gradually crept along the line until our own front became involved. That it was nothing serious could be seen from the innumerable flares sent up by both sides. The "Owies" zipped

through the trees in a most uncomfortable fashion, and were accompanied by a number of whizz-bangs thrown promiscuously into the WOOD. This firing had died down and the quiet was interrupted just now and then by baby hoorooshes, when suddenly there was another eruption, this time from Hill 60 on the extreme right; it was a wonderful sight from the top of the ridge, Hill 60 is not visible but the air all round it was spitting with fire and brimstone. Countless flares in an unending stream rose and fell throwing their brilliant and shadowy light around, intermingled with which was the red glare of bursting shells. From the distance could be heard the rattle of machine guns and rifle fire, mingled with the roar of the cannonade and the thumping of the high explosive shells; and one pitied those striving, struggling souls battling in the darkness for possession of the summit of a tiny little eminence, not yet of vast importance.

Again the rattle of the musketry swept along the line, and again our front was involved. It passed, and ceased, and silence came again. What had happened? The morning would tell and we all waited anxiously. Throughout the night the battle raged on the extreme right and storm followed hell until dawn broke. Hill 60 had been captured and held against numerous counter-attacks.

* * *

Lieut-Colonel K B Godsell, DSO, MC, died on 6 August 1959, aged 66. He had a distinguished career in World War I. After the War he served in Turkey and Malta and attended Staff College. Although he retired early (1928) he was recalled for the whole of the 1939–45 War where he was mainly concerned with Bomb Disposal.

We are grateful to his family for their permission to publish these extracts from his diary of a young subaltern. He has made a part of World War I live to those of us who were fortunate enough to miss it.

A Field Squadron—Airfields?

CAPTAIN C E E SLOAN, RE, B Eng (Hons)

AN UNVERIFIED SUPPOSITION

THE reason for this article arises mainly from the writer's own sense of guilt for having maintained such a prejudiced ignorance of the type of unit he later had the good fortune to join. Although it is a bold leap from specific to general, it is suspected that the title of this paper may reveal the typical reaction of many Sappers when confronted with one of their fellows from Waterbeach. The urgency to remove the enigma which is an Airfields unit has increased with the approach of 1977. By the end of that year of restructuring, each of the four regular engineer regiments in the United Kingdom will have in its midst a Field Squadron (Construction), the immediate successor of the Field Squadron (Airfields). It would appear now more appropriate than ever to introduce (it is feared) or recall (it is hoped) the history and roles of this specialist squadron.

CHRONICLE

There are three Field Squadrons (Airfields), numbered 51, 52, and 53, each with a slightly different history and formation date. However, they all form part of 39 Engineer Regiment (Airfields) based at Waterbeach Barracks near Cambridge.

In 1967 the Regiment took over prime responsibility for the construction engineering support to the Royal Air Force from the Airfield Construction Branch of the RAF. Since that time the squadrons have been deployed on many occasions in direct support of the RAF. The concrete runway at RAF El Adem was extended in 1968 and in the same year the Beef Island Airfield project commenced. With the changing and reducing commitments of all Services such impressive opportunities

did not reappear, but up to the present day equally essential tasks have been executed by the squadrons. Examples of such work requested by the RAF would be the installation of Rotary Hydraulic Arrester Gears and erection of Frankenstein Hangars.

There is, however, one truly central and specialist role for which each squadron is equipped and trained. This is the capability to carry out Airfield Damage Repair (ADR) on its associated RAF operational airfield in Germany.

RAISON D'ETRE

The results of an attack on an airfield by any or all of the weapon systems available to enemy forces might result in the following damage: cratered runways, cannon marked taxi-ways, ruptured power lines, holed fuel or water pipelines and demolished buildings. This short, and by no means exhaustive, list of possible damage immediately suggests that a unique organization will be required to meet the many demands placed on it by an RAF Station Commander, eager to generate aircraft from his base and to maintain the vital resource systems to support them. Major Farmbrough's article in the June 1976 issue of this *Journal* provided a good introduction to the type of damage to be met.

Establishment

An Airfields squadron is appropriately established to meet the requirement of Rapid Runway Repair (RRR) and the maintenance or repair of Electrical and Mechanical (E & M) facilities. The OC is inevitably a PQE officer supported by a Garrison Engineer (GE) and Electrical & Mechanical Officer (E&MO). Each of whom in turn have Clerks of Works (Civil, Electrical & Mechanical) to assist them. This wealth of engineering knowledge is on call to the three Construction troops who form the RRR teams and also provide the E & M tradesmen as required. An HQ and a Support Troop supply the services typically rendered by such sub-units, and complete the outline picture of the squadron organization.

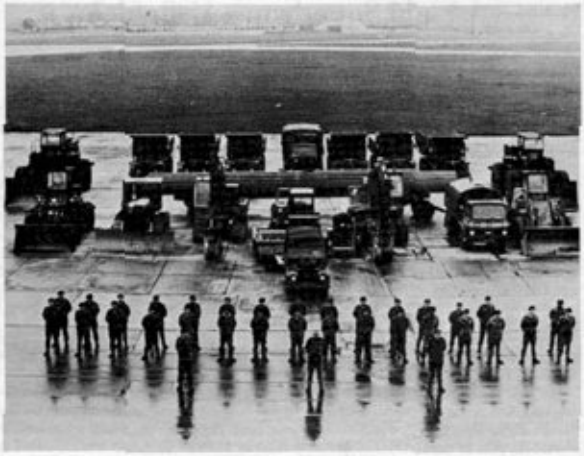


Photo 1. An RRR Team formed from the men and equipment of a Construction Troop (Screed Beam not shown).

A Field Squadron-Airfields?

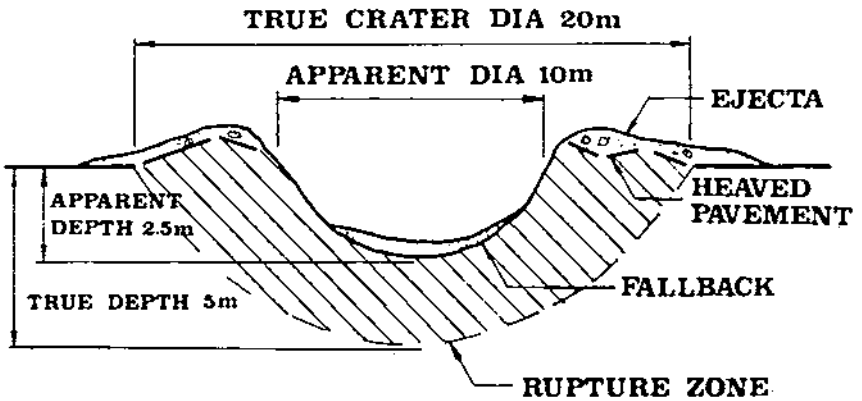


Photo 2. The NATO Standard Crater.

To carry out the RRR tasks an unusually large amount of plant is held on establishment. A standard RRR team with its equipment is shown in Photo 1. A brief review of the less usual plant follows. The scene stealer is inevitably the Michigan 275 Heavy Wheeled Tractor; a huge machine with a 6cu yd bucket. To speed the repair Aveling Barford Dump Trucks are fitted with extension sides increasing their capacity to 15cu yd. Although now in service in Northern Ireland, the Atlas Wheeled Excavator is primarily used within RRR teams to remove heave and ejecta from the crater. For repairs at night high intensity mobile lighting towers are used. Finally, two less exciting, but vital, machines are the Lacre Suction Sweeper and the Arrow Hydraulic Hammer. The latter has proved particularly effective in trimming the edges off jagged concrete at the crater lip.

Requirements

The aim of RRR is to provide a minimum strip, normally parallel to the axis of the damaged runway or taxi-way, which will allow aircraft to take off within a few hours of the enemy attack. This is a NATO requirement which the British system of crater repair (outlined below) has achieved under various tactical, seasonal and visibility conditions. RRR consists of:

(1) Reconnaissance and reporting of the damaged area.
(2) Plotting the damage, deducing the minimum strips possible, and advising the RAF of their options.
(3) Crater Repair.
(4) Scab Repair.

The reconnaissance and plotting phases are concurrent, and since they are reasonably specialized will not be expanded upon. The crater and scab repair are activities which several readers are likely to observe, and possibly take part in, and will now be summarised.

Crater Repair

In this sphere a crater is defined as a cavity which extends below the lower surface of the concrete forming the runway or taxi-way. There is, unbelievably but helpfully, a NATO Standard Crater which is used as the normal training parameter. A diagram of such a crater is at Photo 2. The system of repair is simply to remove all the released materials, dislodge heaved and weakened concrete and back-fill with compacted aggregate, surfacing the now full crater with a bolted-down Class 60 alloy tracking mat. In slightly more detail the procedure is as follows.

The ejecta is removed from the crater edge by the Michigan HWT and Allis Chalmers MWTs to an area where it is spread by a Caterpillar MCT. A grader will also be operating at a short distance from the crater removing waste produced by the explosion. It is necessary to remove and level this material in order to prevent Foreign Object Damage (FOD) to the jet aircraft.

Photo 3. Plant activity at the crater, approximately halfway through the repair.

Once access is possible the Atlas excavators will clear the heaved concrete to a position for the MWT to remove it. Damaged pavement material can also be cut back by the Arrow Hydraulic Hammer.

At the stockpiles the increased capacity Dump Trucks are loaded with 45–65mm single size aggregate. This is used to back fill the crater to within 500mm of the pavement surface. The final 500mm is completed by compacting, in two layers, loads comprising 11–16mm stone. A finely levelled surface is achieved by the use of a long, hollow steel scraper known as a *Screed Beam*.

A repair mat measuring 22mm by 17m is brought on to site by a Michigan HWT and rolled out by hand using almost the entire team. The repair mat is Class 60 trackway fitted with ramps, and rawl-bolted to the concrete. Bolting is achieved by preparing the holes with electrically driven Kango drills.

Finally the mat must be swept throughly by hand, and the surrounding area is cleared by the Lacre Sweeper, before the RAF are invited to inspect the repair as acceptable for safe-loading by an aircraft.

It will be seen that the total repair requires a good deal of training, cooperation and integration within the troop. This presents an unusual and useful opportunity for combat engineers, drivers and plant operators to work closely together and to recognize their inter-dependence upon each other's skills and expertise.

Scab Repair

A runway or taxi-way can also be put out of action by cannon or rocket fire. The effect such armaments can produce is known as scabbing, whereby the cavity does not penetrate the total pavement depth and is generally less than 1m wide. Trials have *shown that linear or area scabbing may arise and these damage effects can as easily* prevent a high performance aircraft from taking off, as can a crater.

Several solutions have been sought to scab repair, all of which are labour intensive. An epoxy resin filler was tried, which produced an effective repair, but the preparation process appeared to require too high an operator skill for the environ-

ment and success rate required. A more recent possibility was the capping of the scab with a mild steel plate. This was rawl-bolted into place with a HILTI gun or Kango drills. Another method which is still under trial is the use of rapid hardening asphalt.

Developments

The techniques of RRR, and the equipment involved, are always under improvement. The most recent addition to the crater repair team's holding of specialist items is the 6kVA generator set which is mounted in a three-quarter ton trailer. This generator set is easily towed behind the troop commander's rover and provides an immediate power supply for the six Kango drills required for Class 60 mat emplacement.

A new type of trailer was also required for the movement of the Screed Beam and the Class 60 Mat. The Screed Beam itself is of only recent manufacture. Its purpose is to skim off excess aggregate above the surface of the surrounding concrete runway, thereby ensuring that the mat is positioned as level as possible.

A development which has much wider applications is the introduction of radio sets for use in the plant employed on crater repair. Because of the close proximity and concurrent activity of plant at the crater site a much greater degree of control has to be exercised over the plant operators and dump truck drivers than is normally required on a construction site. This control will be exercised through Pye fixed-channel radio sets fitted into the operator's cab. The flexibility offered by this communication system may well suggest its suitability for adoption in other situations where close and detailed control over the operator is essential. An immediate example of its use might be in guiding the excavation of field defences at night when the use of lights is not permitted.

Support Facilities

A Station Commander may be primarily interested in obtaining sufficient runway to allow his aircraft to take off, but he will also wish to retain the provision of power, fuel and water to enable his station to function as normally as possible. For

Photo 4. A percentage of the squadron plant is permanently stored on the RAF airfield. Here an Atlas excavator is being installed in its protective envelope.

A Field Squadron-Airfields? (4)

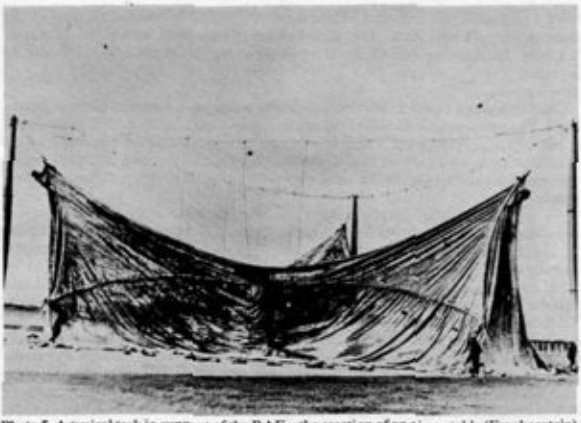


Photo 5. A typical task in support of the RAF—the erection of an airportable (Frankenstein) hangar.

this reason the Electrical and Mechanical aspects of ADR are not neglected within the Airfields squadron.

Training on the latest exercise in which a squadron was deployed to its airfield (Exercise Cedar Strip II) included the following:

(1) E & M damage recces as part of the station MINEVAL—an exercise designed to evaluate the tactical readiness of an airfield.
(2) The installation of Bulk Fuel Installations by 503 STRE (V) assisted by squadron personnel.
(3) A high-voltage cable repair.
(4) The running of the airfield power station by a shift of unit electricians.
(5) Familiarization visits to the boiler house, pumping stations, electricity sub-stations and water sources.

In future the E & MO, Clerks of Works (Electrical) and (Mechanical) plus E & M Draughtsmen will be attached to the airfield for six to eight weeks each year. During this time they will acquaint themselves as fully as possible with the E & M services and update the technical dossier held by the squadron on such services. Liaison with PSA (DOE) during these attachments will be essential, and an excellent level of mutual cooperation is expected to result from these visits. The value of such a bond, both in war and for exercises, cannot be stressed too highly.

PROTEAN

Despite its unique establishment and scaling, an Airfields squadron is expected, and able, to carry out any of the many diverse tasks which a normal Field Squadron may be called upon to do.

Within the last two years Airfields squadrons have been on operational tours in Northern Ireland. They have taken part in projects in Canada, Belize and Gibraltar. A little closer to Waterbeach, a composite troop was provided for Op Slant in Glasgow during the dustmen's strike, and an urban guerrilla training alley was erected near Colchester. Each squadron attends an annual bridging camp, and combat engineer training exercises are also undertaken.

In view of the role of the unit emphasis is placed on physical fitness, "Shoot to

A Field Squadron-Airfields? (5)

Kill" practices, and the ability to live and work in a nuclear or chemical environment. These examples will illustrate the variety of tasks and training which are met in an Airfields squadron in addition to the minor projects and priority role support which they undertake for the RAF.

RESUMÉ

Within a short time of this article being published, four Field Squadrons (Construction) will come into being. They will be accommodated with, and work alongside, Field Squadrons in Engineer Regiments. The pace of life today often precludes our being fully aware of the functions, problems and capabilities of even our immediate neighbours. It is hoped that this digest on an Airfields Squadron will prepare members and partners of the new Construction sub-units for the immediate challenge of genesis. More generally, the article will have been successful if more people are now aware of the typical duties of an Airfields squadron. The squadrons at Waterbeach may be set back from the main road to Cambridge, but they are far from outside the main stream of Corps activities.

Early Days

MLC

"THE chief extension of the use of the Institution has been the provision of lectures at large outstations of a similar class to those given at Woolwich; those arranged were very successful. The Committee have to be careful lest lectures be overdone and interest in them lost. The Committee were much pleased that two out of the first four of these lectures should have been given by Officers of the Royal Engineers. . . . The Committee have every reason to congratulate themselves on this new feature in the advantages of the Institution."

Under the title of "Branch Meetings" the RE Institution has recently been congratulating itself on the success of a like enterprise. The fact that the Royal Artillery Institution was similarly congratulating itself nearly one hundred years ago need not detract from our present success! To the contrary (given time), what the Artillery can do, it is axiomatic that the Sappers . . .!

The quotation at the start of this article is taken from an account of their 1896 AGM printed in the "*Proceedings of the Royal Artillery Institution*" for that year. That the Proceedings for 1876 are not to hand is unfortunate. It seems that the Gunners started their publication in 1873 although as readers may remember the RA Institution itself was founded in 1837. However, according to the Cambridge University Library, volumes earlier than 1896 were mostly out of print in 1904, let alone in 1976!

The two lectures mentioned above as being given by RE Officers to Artillery outstations were "Incidents in Bush Warfare" by Major W D Conner RE and "The Nile and its Tributaries" by Lieut-Colonel C M Watson CMG RE. In the discussion following Major Conner's lecture a questioner (presumably a gunner officer) commented "The spirit of the age runs into division of labour and of professions into branches. The engineer nowadays is no longer a general factotum, but either a bridge, a mining, a railway or an electrical engineer. This applies, in my humble opinion, as much to military as to civil engineering. The former should be split up into submarine mining, electrical, fortifications, buildings etc departments, the officers being kept as much as possible for good and all in the various branches. Besides the above, there is a minor branch which hitherto has not received in the British Army the attention it deserved—it is that of pioneering. I am strongly in favour of a strong corps of pioneers being raised . . .". The questioner went on to detail exactly how he thought such a Corps should be trained and raised, recommending possible training manuals, one being "a very good manual used at West Point". He further advocated that "they serve as trainers of our regular infantry, whenever it became necessary to employ them for road making and military works during field operations".

The age old controversy between the "generalist" and "specialist" will no doubt continue! Conner did not comment on this part of the discussion--probably wisely so. Twenty years before (that is, in 1876) in an article—this time (curiously enough) in the *RE Journal*—about defending Fortresses, there is a spirited plea for dividing the gunners into Fortress and Field Artillery, the officers quite firmly and for "good and all" being assigned to one branch or the other. Objections that to do so would mean that Fortress troops might lose "their military qualities" and that it would be difficult "to get officers for the Fortress Artillery" were dismissed in one terse phrase, "Such objections seem to have little foundation"!

Promotion and retirement is an ever recurring subject in most Service Journals and 1876 was no exception as far as the *RE Journal* was concerned. In February the Editor recorded that in 1875 out of a total of fifty-three Lieut-Colonels and seventy-eight Majors none were promoted, and out of 126 Captains and 371 Lieutenants only two and nine were promoted respectively. "These figures are ominous indeed", and the Editor "hesitated to add in fancy" what the future might bring. The Editor felt that "A *law* by whose quiet action a fair and even flow of promotion was secured would seem to be the thing wanted". It "would seem" that the Army had to wait just about 100 years before such a law, quiet or otherwise, was to operate!

In the aforementioned *RA Proceedings* for 1896 there is, somewhat surprisingly, a forecast of promotions likely to be made during the next eight years of certain Majors, Captains and Lieutenants by *name*. How the AAG RA reacted to these named forecasts, history does not relate! It seems to be an interesting example of how possible misunderstanding about the respective responsibilities of an Institution *vis-à-vis* the Established organization, could arise. For instance, the Corps might have verged on such a controversy when certain proposals were made about re-organization within the RE Institution in 1960/61. One of the possibilities then discussed was that membership of the Institution should be looked upon as a qualification for enhancing professional status. Scholastic attainments and military engineering experience were to be taken into account before membership was granted—presumably by the Council of the Institution and not by AG7.

In the September 1876 *Journal* are printed extracts from the "Report by the Royal Commission on Army Promotion and Retirement", in so far as that report concerned RE Officers. It seems that promotion blocks were such that the only remedy was the introduction of a "redundancy" scheme. The Royal Commission was concerned to provide acceptable terms. For instance, the Commission recommended that a Major after nineteen years service should receive a lump sum of £2,357—a fairly handsome sum in those days. Alternatively, Majors, on completion of seven years as substantive Major, and with not less than twenty-seven years service could have elected compulsory retirement on £300 per year with an immediate step in honorary rank. Regimental Lieut-Colonels, on completion of five years service as substantive Lieut-Colonel would be able to retire with a pension of £450 per year plus the honorary rank of Major-General, the latter to be granted from the date at which it would have accrued to them had they remained in the service. The possibility of gaining generous honorary promotion on retirement could have been an attractive carrot and is a marked departure from the way such things have been regulated since.

The rules for retirement and retired pay at that time were anyway somewhat complicated. For instance after twenty-five years any officer could retire on half pay, and after thirty years he could retire on full pay—but only subject to there being enough money to pay him the extra increment! There was, for instance, a lump sum of £16,000 available to make up Colonels' pensions to a greater sum than the £500 pa half pay to which they were entitled. There were different rules for, for example, the Engineers, the Artillery and the Line. In 1871, in order to relieve a block in the Artillery due to too many subalterns having been commissioned, such officers were allowed to retire on an annuity of £51 per year. This scheme was tried with success as far as "getting rid of the officers went, but (in 1876) some of them are most anxious to get back again, being in poverty". Since, however, it was agreed that "men who

have had training as engineers would have no difficulty in finding civil employment if they left the Corps when they were full of life and energy", the Commission concluded that a like scheme could be successfully introduced into the Royal Engineers, to relieve a similar block in the promotion of subalterns. It is difficult to make out why AG6 and AG7 had miscalculated so badly in determining the numbers to be commissioned from the RMA Woolwich in the first place.

The Army Estimates in 1876 had a reasonably smooth passage although a certain Mr J Holms MP was stumping the country accusing the Army, both as regards its constitution and its administration, of being "completely and fundamentally rotten". Its expenditure was alleged to be enormous when measured against the number of effective soldiers. Mr Holms could not determine whether this was due to the appallingly high costs per soldier, or because of mere waste and maladministration. The Editor, in a remarkably balanced summary of Mr Holms' criticisms, commented that "the onlooker often sees most of the game and Mr Holms' views are at all events fresh". The Editor further reminds his readers that the British Army is a structure that had grown somewhat haphazardly to its present form—a "building patched from time to time by cunning architects . . . each adds a wing and by some temporary expedient props the inclining wall. It has grown as a coral reef—by accidental agglomeration—not by intelligent construction". In his refusal to be prejudiced merely because of the fact of criticism—the Editor seems to have shown a commendable strength of mind!

The Navy Estimates had to be defended more robustly. The First Lord used such resounding phrases as "parsimony is the great enemy of economy" in their defence. He also had to defeat a motion that a Civilian should not be appointed First Lord of the Admiralty, as no Civilian could properly comprehend the problems involved. The House was reminded that a Civilian had, for instance, presided over the Navy during those great years of victory from 1782 to 1815.

Some excitement was caused at Chatham Prison in 1876 by the receipt of a telegram threatening an attack to release three Fenian prisoners. The plan was apparently to set alight to a large wooden vessel in the dockyard factory basin—an extension of which adjoined the prison. Under cover of "this commotion", an attempted landing was to be made to get within the prison walls. In the event no attempt was made. This was reported in the Press but not in the *Journal*. However, the *Journal* did proudly note in February 1876, that a lecture was to be delivered to the "Young Men's Society", in Chatham, but the lecturer was unable to attend at the last moment. In order to prevent disappointment, and at only a few hours notice, Lieutenant Sankey RE undertook to act as substitute and "delivered an effective and interesting lecture on Explosives". Perhaps if this lecture had been even more effective, the attack on the prison might have taken place. Or would that have been looking 100 years ahead!

Plymouth Towards Newport USA Observer Singlehanded Transatlantic Race (Ostar) 1976

CAPTAIN (QM) M W B BEST, RE

NEARLY everyone who sails in a dinghy or cruiser has at one time or another had a secret ambition to cross an ocean but sensibly enough the majority quickly put aside these fantasies and live a normal life, free from worry and financial precipices.

The opportunity for me to join the lunatic fringe came when Major Stuart Rogers and I teamed up to purchase a yacht and enter the 1974 Round Britain Race. After a lot of searching we settled on a multi-hull as being the most likely type of yacht to succeed in what was meant to be an off the wind race. As it happens we met head

winds all the way round, were dismasted off St Kilda, returned to the Hebrides under jury rig, repaired the mast and completed the race, winning the last leg—Lowestoft to Plymouth—in the fastest time forty-five hours. But that is another story.

Croda Way is a 35ft trimaran with a 24ft beam and a working sail area of 630 sq ft. She only weighs 2½ ton and is extremely fast, having been sailed in excess of 20kts by us on several occasions. The accommodation is spartan—two bunks and a cooker aft, navigation area and sail stowage forward. The floats are sealed and provide buoyancy and stability. The main hull is only 3ft wide at water level.

The expense of racing and maintaining such a machine was far beyond the means of Stuart and I but after writing over a hundred letters, our fairy godmother, Croda International Ltd, offered to sponsor us, hence the yacht's name.

All potential competitors for OSTAR must complete a qualifying sail of 500 miles alone. This I did in 1975, returning singlehanded from the Azores, after having raced there with a full crew against other multi-hulls.

Plymouth Towards Newport USA Ostar 1976

The winter of 1975 was spent improving *Croda Way* and preparing her for her 3,000 miles Atlantic crossing, including fitting additional equipment such as:

(1) Solar panels for battery charging.
(2) Electric-self-steering for use in light weather.
(3) Wind operated self-steering.
(4) Automatic sheet release which can be set to release the sheet at a predetermined angle and prevent a capsize.
(5) Repeater instruments to enable me to note changes in wind speed and direction while lying in my bunk.
(6) VHF radio for talking to passing ships and shore stations.
(7) Steps up the mast.
(8) Astro-Dome for all round observation without going on deck.
(9) Clansman 320 radio for talking to Chattenden.

Planning food and rough menus kept my mother busy for the whole winter. Tins of stew and beans are alright for a few days but a month's hard sailing requires a properly balanced diet to keep the crew in peak condition. Only fifteen gallons of water were carried to keep the weight down, an important criterion in performance multi-hulls, and after a final scrub and bottom polish at Chatham we set off for Plymouth.

After extensive scrutineering by race officials, *Croda Way* received her acceptance certificate from the Royal Western Yacht Club and on Saturday 5 June we were towed out of Millbay Dock to join the milling throng of yachts, spectators and competitors gathering for the start of OSTAR 1976.

The text of the story that follows is taken directly from tape recordings I made at various times each day. I have edited them slightly to make the odd points clearer to the reader but I have made no attempt to hide my feelings, fears, elation or fits of depression felt during the race. I was in daily contact with my home unit at Chatham and with three other yachts: *Flying Angel* (Lieut-Colonel Jock Brazier RE), *Wild Rival* (Lieut-Commander Geoffrey Hales RN), and a Contessa 25, *Galadriel of Lothlorion* (Captain Nigel Lang RA). All these three feature in the story. The map shows my course with daily positions indicated by the date figure.

THE RACE

Saturday 5 June

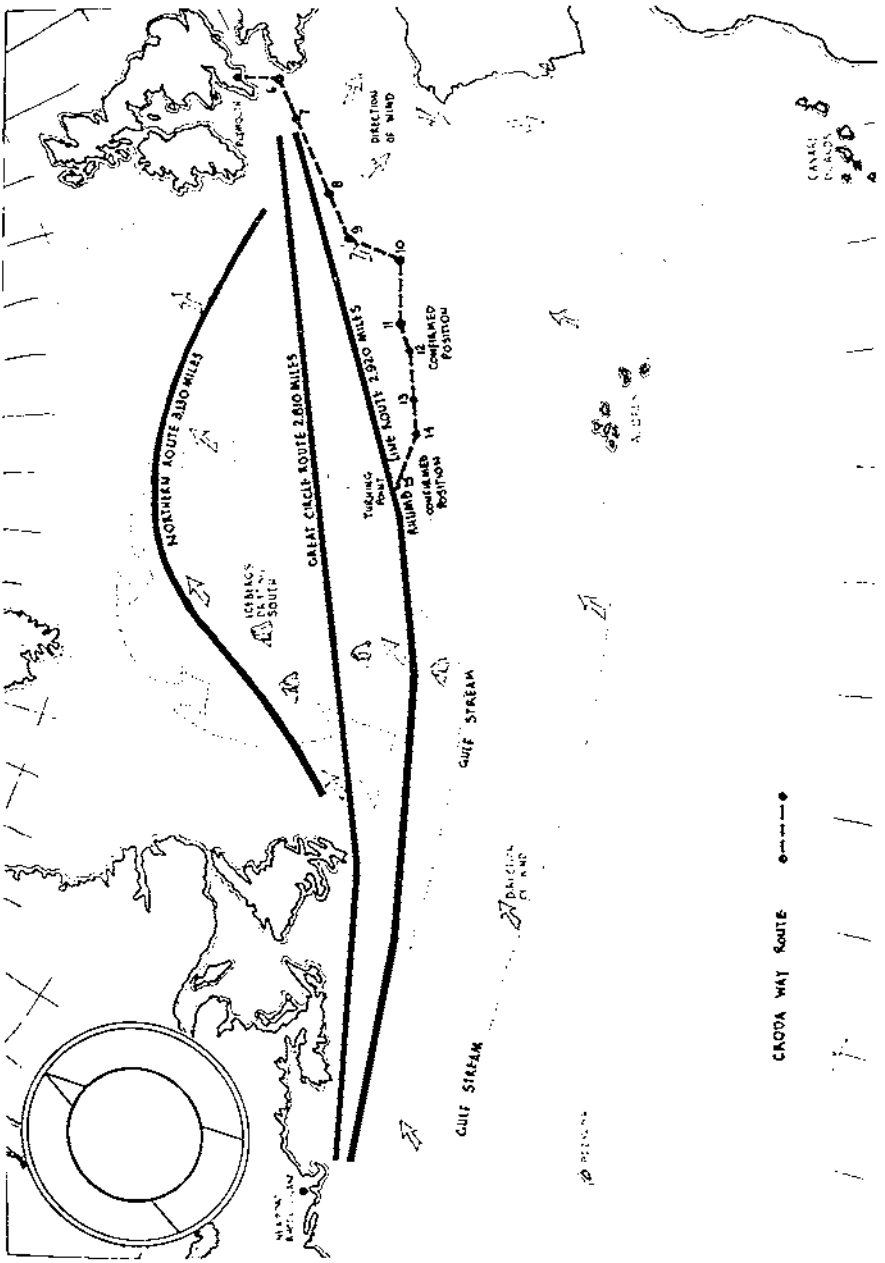
Our start was not until 1230 hrs, so we milled about in Plymouth Sound waiting for the "off". A launch chartered by Croda International came alongside bringing Lesley Judd and the "Blue Peter" TV crew, who were to film us crossing the start line. Terrific excitement. Countless yachts sailing around, helicopters and aeroplanes overhead. An unforgettable sight.

Made a reasonable start but unfortunately was baulked soon after by a biggish yacht which took our wind away. I think I had the wrong rig up for the start—the big Yankee and the staysail—not much good at all, in such light airs. Only making about 3 knots to windward, so as soon as we were clear of the yachts I changed to the big Genoa. Now making a steady 4–5 knots.

It is now 18.55 and am still in contention with the 236ft *Club Mediterranean* and just to the windward of us the 128ft *ITT Oceanic* and I've just seen what was *British Oxygen* (now *Kriter III*) go across my bow. Not particularly good—a whole group of yachts kept inshore and got clear away by keeping close to land. We're headed on a course of about 180° at the moment—reasonable—wind blowing a not encouraging 12 knots from the south-west. Some shipping about. Have a cold—tiresome.

0700 hours, Sunday 6 June

Very overcast this morning. Identified yacht lights last night but only one yacht visible this morning down to leeward. Don't know who she is. Still have a cold (sniff!) plus accompanying aches and pains. Had a cup of tea; listened to shipping forecast—gloomy. Calm around Scilly Isles so those sailing farther north than I are probably having a hard time. Am about 30 miles to the north of Ushant on a course


NORTHERN ROUTE 3,130 MILES
GREAT CIRCLE ROUTE 2,810 MILES
LINE ROUTE 2,920 MILES
TURNING POINT
CONFIRMED POSITION
CONFIRMED POSITION
DIRECTION OF WIND
GULF STREAM
GULF STREAM
CRODA WAY ROUTE

of about 260° at just over 4 knots with 10 recorded knots of wind speed. Not bad, I suppose. The big Genoa is up and the main so we're going on happily. Sea calm—first of the big Atlantic swells—gentle, rolling—nice and pleasant.

Midday, Monday 7 June

According to Meridian sight my position is good. Wind about Force 4. Making between 8 and 12 knots which is great after being virtually becalmed for so long yesterday. Managed to do about 120 miles between sights and am well clear of shipping lanes. Will be able to sleep more peacefully. Haven't seen anything today—not even a bird—surprising. Usually get the odd gull or stormy petrel following. Another beautiful clear day. Sea bit bumpy—deep indigo blue with white caps. Hammering along.

1600 hours, Monday 7 June

Just had good radio contact with Chattenden. Heard from *Flying Angel*—she really is flying and must be about 20/30 miles ahead of me, going north, whilst I try to work my way south. Some trouble with self-steering gear. The pendulum blade kept jumping out and it was quite a struggle to get it back again. Managed it after the third attempt and tied it temporarily. It's the first time I've got wet on this trip. The steering at the moment is a bit erratic—I think I'll make a sail change. Cloudless sky all day—some mares' tails just beginning to appear. Usually a sign of continuing fine weather and, with a nice breeze like this, will be happy.

0830 hours, Tuesday 8 June

Made very good progress last night—during 24 hours from midnight to midnight 140 miles. I need to do this each day to get across in respectable time. Wind now between Force 4 and 5. Still got the same rig up. Grey overcast morning. Special weather forecast at 3.30 warning of depression somewhere in mid-Atlantic. Hope we're going to miss it. Not very deep but wind will be in the wrong direction for me. Centre board vibrating noisily as we touch up to 12 knots. Exciting. Spray flying through air. The poor little charging engine on the back is wet through. Still, can't be helped. It slows my sleeping down, but have managed 3–4 hours at a time. Think I had six one day. Not too bad. Feel OK. Here we go again—the whole boat is vibrating under me as we surge ahead, surfing fast.

1630 hours, Tuesday 8 June

It's all been happening this afternoon. The wind has increased steadily blowing between 30 and 35 knots, which is the top of the Seven. Had to drop the big Yankee and put up the staysail. Mast bending very badly so dropped the staysail. Time for radio check. I've been talking to everybody for half an hour. It appears the other boats are doing well particularly *Flying Angel* who is sweeping along still, a fair bit in front of me. Have tightened up one of the running backstays, put the staysail up again and taken the slab reef in the main. We're hammering along between 8 and 9 knots on a course of about 265°m. The sea is lumpy—crashing over it. Still a bit of bend in the mast. Eased the main backstay. Looks OK.

Heard from Geoffrey Hales in *Wild Rival*. He passed boat No 134; saw a frigate and a Nimrod aeroplane standing by. Could be that it was in trouble—I hope not. He also saw another, No. 153. They are both in his Class. He's going quite well and Jock Brazier said he was alongside *Wild Rocket* (Penduik Class) earlier. I would say that the multi-hulls that have taken the northern route will be going very well. Still trying to make our way south. Our true course is about 250° and that should take us west of the Azores.

You can probably hear the bumps and bangs—it makes my voice jerky as we crash over the waves. Quite exhausting. Had good meal for lunch—threw the fresh sausages overboard before they walked there. Feel fine. That's all for now.

It's now 2150 GMT, Tuesday 8 June

There was a vicious rain squall just now. Didn't see it coming though we've had a few coming through during the day. This was the worst—it blew about 45 knots and "pop" went the main. Great rip in one panel above the reef. I had her down to one reef so rushed out on deck; dropped the main altogether. It's a good thing we

had that crash bar over the Astro-Dome, otherwise the boom could have broken the dome when the main went.

Went back below, dried off; donned oilskins and took in the second reef (which was above the rip) and naturally the wind dropped. Now blowing about 20 knots and with the two big reefs in and the number one staysail, we're only doing about 5 knots. This means oilskins again; going out and putting up a bigger foresail. In fact the full main is only 180 sq ft on this boat. It's smaller than ever now but I reckon that until the weather improves I can manage with making full use of the fore-triangle. As long as we don't have to go too hard to windward, when I don't think it will give us enough drive. A pity, because it means we will have more tendency to bear away all the time, but I reckon about 6 or 7 hours sewing and I might have the main suitable for use in light weather.

Midday, Wednesday 9 June

Only just sailing properly again after last night. First the running backstay parted from the lever. Had to repair that using bulldog grips. The big Yankee started to split at the bottom and I've now changed all the sails; got the No 2 staysail set and the No 2 Yankee hanked on the forestay, not up. The wind is registered at 20 knots but I think it's more. Vicious gust a few minutes ago. That really whistled down and hit the 40 knot mark in seconds. Barometer going up very fast indeed—sign of a bit of breeze. Only had time for coffee this morning. Quite incredible—without the running backstay the mast bent considerably. Getting to the point now that if anything else breaks—I just don't know! Quite a bit of sewing to do; would like a decent steady breeze. Am making course just about south. Pretty hopeless! Haven't seen anything or anybody for a long time. Wet through! Saturated! Am sucking a humbug to get the taste of salt out of my mouth. I don't know why the devil I'm here (partly sung)!

2100 hours, Wednesday 9 June

The wind's gone down—I've got the No 2 Yankee, No 2 staysail and this double reef main, all pulling well. Doing 8 knots—dead to windward as usual—course about 290°m. We were going about 180°m so I tacked and instead of pointing east of the Azores we are now heading towards America. It goes against the grain to head away from our destination though we intend to go down to the Azores. Will wait till we get a decent slant then move slowly south. Heard from our other three stations who have all been through the gale that hit us last night. They're worn out. *Flying Angel* said he had been fore-reaching at about 3 knots for about 18 hours and the others haven't done much better. I appeared luckier as the gale seemed to go through quicker. Although pretty unpleasant while it lasted (it did a lot of damage) but all is well.

Have sewn up the staysail. Must attack the main but not until I get some decent weather. Going alright, not too fast but that's because we're going to windward. Once off the wind we pick up speed.

Am now heading towards some pretty darkish-looking clouds which means we are in for another blow. The sky is overcast with a high whitish film of cloud and it is getting much darker below. Looks like rain. Not a very encouraging sight as far as local weather forecasting is concerned. We may miss it—but I think we're going to get very wet in a minute. Fortunately, unless something breaks, I don't have to go on deck. Now, no matter what happens, whether it flaps, cracks or bangs, I still put on my oilskins before I go up. No more of this rushing around getting wet, I'm rapidly running out of dry clothes. Am also gibbering too much.

Talked to Chatham on the radio and I believe that Alice is going up there tomorrow to listen to some recordings of previous transmissions. Hope what she hears doesn't worry her—I'm still quite happy and all OK.

It's 2225 on the evening of Thursday 10 June

Poor radio contact this evening in bad conditions—but managed to get our reports through. We are now hammering along and have been for some time. Frankly, am scared out of my wits. We must be getting up to 16 knots—the log's

stopped working properly. Only showing 2 knots. Wind about 25 knots but don't know how much of that we're making. Course about right for America. A very hairy sail at the moment. The water is going straight over us. I'm dead tired but daren't sleep just in case something goes. When you're racing—you're racing—you've got to keep going. Another dark miserable night; overcast all day, thick fog and blowing between Force 4 and 6. Generally very depressing. However, had a very good meal—Pork cutlets in wine sauce with Asparagus tips, mashed potatoes, and some coffee, listening to the radio.

Haven't seen another ship and don't want to see one now. We couldn't stop if did . . . (later) . . . Enough is enough. I had to call a halt to that mad tearing rush. It was too frightening for words. Hurtling through a pitch black night at at least 16 knots, hour after hour. I wouldn't mind it in daylight on a lake but not in mid-Atlantic with just about 2,000 miles to go. The wind eventually got up as it is now, between 35 and 40 knots. I had no alternative but to drop the staysail. This has reduced speed to a sedate pace—say between 6 and 8 knots. Can't tell exactly the log's not working at all now.

0800 hours, Friday 11 June

This is what I call a "character building" morning. A series of disasters. Missed the 3.30 weather forecast. Woke up at about 5 o'clock; looked at the various needles in front of me; saw wind direction was the same and windspeed had reduced slightly. Said to myself "That'll be alright". Lo and behold, when I woke an hour later, there was still very little wind—about 20 knots. We were completely headed and bearing away up north. Got up, put on oilskins and tacked. I then put on the staysail and played about with log, trying to get it to work. I found that during our fast run last night the impeller on the log must have whirled off; thus the log hadn't worked all night. Anyway, I've tried to fix it by using the spare impeller. Rather a bodged-up job and its not reading properly yet. Everything wet and miserable. My soft-boiled eggs came out hard-boiled. Not a drop of blue in the sky. All in all, one very depressed person speaking.

Morning, Saturday 12 June

Gale warnings all round—Force 9 to the north of us. Yuk! but in fact the north is having the wind direction we should be having down here—they're getting easterlies and we're getting westerlies. Doesn't seem fair. However, maybe things will sort themselves out later. Wind's going down—blowing about 25 before—now about 18 knots. Got the No 2 Yankee, No 2 staysail and this tiny main that we've got left. As soon as we get off the wind (if!) I'll get sewing. Good contact last night with Chatham. Made ourselves heard and got position from all the other boats. Generally, everything going well. Had a good breakfast, scrambled eggs, bacon, coffee, fruit juice—all the usual things. Haven't had a shave yet. Will have one within the next couple of days. I find this boat remarkably cramped and am always screwed up. You don't go on deck in this weather. With the gale warnings around I've taped up the hatches to prevent leaks.

Now 3 o'clock on the afternoon of Saturday 12 June

Still rushing along at a steady 7 to 8 knots. Blowing hard and slowly increasing. It cleared up beautifully at one stage—not a cloud in the sky. Now it's overcast—just a layer of cloud which in fact depicts more wind so we could be in for more excitement. Another radio contact at 11 o'clock with Chatham. Up in the north Jock Brazier in *Flying Angel* and Geoff Hales in *Wild Rival* are having quite a time. They've been in a Force 9 gale for so long they think it's a way of life! Down here we've been much luckier. I tried to sleep a few minutes ago but we did a nose dive and by nose dive I MEAN nose dive. Straight off a wave and through another. I really thought I had the back end of the boat sealed up, but a dribble came through right on my head from the hatch. Got it sealed up now with black tape. It should be better. I did take the staysail down a little while ago. Have just got the Yankee and the small main.

No difference to our speed. Hammering along. Difficult problem of contemplating

what I'm going to have for lunch—cum tea—cum supper. I could do with a good bath. The back end of this boat looks more like a floating ash tray than anything else. Disgusting! What we need is a nice fine following breeze for a couple of days to give us a chance to dry out and warm up. A slight rattle on one of the floats. The supports to the floats were cut at one stage to make them demountable. They were joined together with a sleeve and fastened with rivets and bolts but one of them is rattling a bit. When things quieten down I must have a go at doing something about it. Still, not to worry.

Great excitement this morning. I saw a ship, fairly close—a big cargo boat. I was rushing from radio to radio. The Army radio's in the stern here and I put that on to 2182 and tried to contact him—no success—rushed to the front end, tried to get him on VHF. Eventually he replied. Didn't speak English very well. Anyway I managed to get the message over and he confirmed my position which pleased me no end. I was within 10 miles of where I thought I was. Considering I've been doing it on dead reckoning with about four sun sights since we left Plymouth seven days ago (and they were *very* dodgy sights) it was more good luck than judgment.

Still Saturday 12 June

It's now five minutes to nine. Have changed headsails as the wind was dropping off. Put up the big Genoa and taken off the No 2 Yankee—big change—and now of course the wind's coming up again. I've also got the generator going, charging up the radio batteries and am trying to do something about this float support. Not too good, needs clamping up more. I've been playing about with that for a while and am now going to have a really good cup of coffee with fresh cream and a bowl of fruit or something. What else! Oh, yes. Terribly important. The log, the impeller (the second impeller) has come off. This means I have no way of recording my speed or distance. This doesn't matter too much if I can get the odd sun sight. Could be worrying close inshore particularly if there's fog. It also means that when I'm asleep I have to estimate speeds. Here come the waves again—no blue sky up there at all. This morning was glorious, a bit windy of course, but I thought we were in for a great day. Then, from 1030 onwards, it's been completely overcast. Now we've had fog. This has cleared but I can't see anything worth seeing.

0900 hours, morning of Sunday 13 June

Went to bed last night at 0030 feeling very tired. Didn't have much time to sleep during the day with various jobs to do. Set the alarm and wireless alarm to 0300 hours in time for the shipping forecast. 0700 hours this morning I woke up. My first reaction was—well! I've done it again. I looked at the course, the wind indicators, and they were exactly as they were when I went to sleep which means we've been sailing pretty steadily through the night between 7 and 8 knots. Without the log I can't tell. No sun today—completely overcast—it might break later. I'd like to take a fix to see whether my estimated speed is right. My course is a steady 305/310°m which means I'm now definitely heading for the Rhumb Line route. Don't think I can afford to go south now so I'll stay on this course and let the wind do its worst.

Wasn't able to do much about fixing that float support last night. I'll have another go today. Even with this double reef main the boat seems to be quite nicely balanced. I might try a larger Yankee later. I've got the generator on outside at the moment. Don't want to go too fast as too much spray will douse the generator and that's one machine we must keep going.

Had a very good breakfast and I'm having a second cup of coffee and a cigarette before we start . . . (later) . . . Very poor radio contact tonight. Wind about 25 knots. It hasn't been blowing all that hard today although it's been threatening. Have managed to get quite good news over the air. I'm 170 miles in front of *FT*, another 35ft trimaran and seem to be right up with the leaders which is most gratifying. Saw a ship today. It didn't bother to talk to me. Saw three dolphins jumping around—they didn't talk to me either, so I was glad to get on the air. It was a pity it wasn't a good night for communications; I felt like a chat. Managed to get a couple of quick sun sights in today; otherwise its been overcast, foggy and cloudy—the same old

pattern. The wind's gone round a bit more southerly so am able to make course of about 260°m doing about 8 knots at an estimate. Haven't been able to get around to that float because we've been bashing to windward and it means that we're covered in spray. I don't want to stop the boat for a couple of hours—it's the float that's out of the water and it's only when we crash into a wave that it comes to any harm.

We had Jock Brazier on the air in *Flying Angel* today and he, sadly, has decided to retire. He couldn't get his self-steering repaired. It was damaged during the gale. She's a big 63ft ketch—too much for him to handle and to steer nearly all the time. I think he's made the right decision. He's obviously a very tired man trying to get the boat going to windward. He said that he couldn't get it to point properly, which you must do to be competitive in a boat that size.

Nigel Lang's *Galadriel of Lothlorion* developed a leak last night but he has managed to fix it . . . (later) . . . It's all been happening in the past couple of hours. Wind increased to Force 6–7 so on with oilskins, big boots, safety harness; went on deck and took down the staysail. This means you have to do one or two other jobs as well such as easing the running backstay and tightening up the main adjustable backstay to get the correct shape in the mast. Having got her settled down I came below feeling refreshed, having been well and truly doused. Took off oilskins and safety harness, looked at instrument again. It was now blowing Force 8. So back into the forward compartment; oilskins on, safety harness on, up on deck, down Yankee, up staysail, tighten up running backstay, loosen off adjustable backstay, and that's it. That's taken approximately ¾ of an hour struggling along in pitch black on a great heaving deck, being continuously covered by water. Gusting almost 40 knots. Going along quite fast through it and if the waves get any bigger will have to stop, which will be a blow.

I have tried to write all this up in the log in the last hour but it's impossible. The pen just won't stay on the paper, and it's a good thing I've got this tape recorder. We've got the staysail and the double reef main, maybe a bit too much but going along quite well and irrespective of what anyone says we are *racing* and I know *FT* is 170 miles behind me.

0440 hours, morning of Monday 14 June

This morning should be the 13th! I've obviously overdone it. At 0300 hours a crack appeared in the fibre glass housing that supports the lower strut of the port float. I immediately hove to. Listened to the 0330 forecast which gave severe gale Force 9 in my area. It's been blowing Force 8 for about 4 hours and we've been crashing on with staysail and main and a dodgy float support. Scraped the paint from around the crack and started fibre-glassing at 0345 hours with the wind howling round and waves knocking us all over the place. Just before glassing I fitted a spare stainless steel wire to the outer ends of the floats, passing it right across the boat. Using the spare staysail halyard fastened to the centre of the wire, I cranked it up tight using the two speed halyard winch on the mast. This has the effect of supporting the floats and absorbing some of the shock effect. Got another pair of trousers wet—last pair—and having done the radio schedule, checked things out, left the boat hove to, and went to bed.

Woke up at 11 o'clock after 3 hours sleep. Still blowing quite hard. I checked the fibre-glassing (all gone off now). Didn't seem too bad. I'd used a lot of accelerator which means it's a bit brittle. There is a slight movement there but it should be alright for a while. I've now improved on the wire frame that I made up from each float and it's now a permanent fixture, holding the floats up tight. A lot of adjustment will be necessary to get the mast right to support this extra weight.

It's now 2 o'clock and I've been sailing for about an hour. Incredibly there's blue sky ahead—the first for days. The sun's out so can take a sunsight and see where I am. Blowing about Force 6—quite big seas after the storm and the best course I can make is about 310°m which is not much good, taking me straight to Newfoundland. I'm just zig-zagging across the Gulf Stream instead of getting out of it. Water has just come in now to join the rest of the water in here. Had the hatch slightly open

above me and took one right over the top. The whole inside of this boat is like a sodden swamp—absolutely saturated. I sat down about 10 minutes ago for my dinner; the pan went flying and finished upside down on a pile of clothes. We were not amused!

Have now decided I can get to the Azores from here in about 2 days and get these repairs done properly. I'm feeling rather dispirited and a bit lonely. Remembered sailing to the Azores last year in lovely sunny weather—we asked for wind then—now we've got it. What I want is two days off the wind with sun so I can dry out and give the boat a good clean. The wind has freshened up again and I've had to put the storm jib on for the first time. Can't tell how fast we're going—probably about 4 knots on a course of about 320°m. The clear blue sky has vanished now and all the symptoms point to another good blow. If anything else goes will have to turn round and go back—absolutely saturated; being driven berserk and how in hell do you get a sunsight with waves towering above you. Have got to get right on top of one to make sure the horizon isn't the next wave. If this one works out right it'll be a miracle.

2120 hours, evening of Monday 14 June

If I've ever thought myself out in an Atlantic gale before, I was mistaken. This is the worst so far—the seas are enormous. I have the storm jib on and I've taken some rolls in the main so that's two big reefs and three rolls. We've practically no sail at all and we were going too fast—to windward! I've now disconnected the self-steering and have locked the wheel to windward. Going along at 1 or 2 knots. The sea is quite incredible. Can't see the horizon because of the waves which now and again completely smother us. Still worried about the float support. All the Baron instruments have stopped working. The windspeed and direction indicators have all given up the ghost.

I don't like the look of that sky—think we're going to have another do tomorrow.

As long as the float holds out we've cracked it. Another two weeks of this and I'll be a physical wreck. I'm certainly not going to do this again—I'm going to take up gardening and give boating a rest for a while. Enough is enough.

There are great walls of sea approaching. The crests seem to reach high in the sky, as we go over the top and down into a trough there's practically no wind at all.

A rogue wave (which comes from the wrong direction) came up from behind—I don't know how, but it got me on the quarter and lifted me up as one was coming from the other end and they did a sandwich job. Needless to say everything was thrown from one side of the boat to the other including me. The automatic sheet release set at 35° has fired three times. A big black cloud ahead is probably near the centre of the storm and I've been hand-steering for about 40 minutes to try and tack but every time I get up speed it becomes really dangerous. Coming over the top of a wave is like standing on the edge of Shakespeare cliff at Dover. There's just nothing underneath but if you are going slowly you settle over the top. It's unbelievable that the boat can survive. If I wasn't so frightened I could go to sleep quite easily. I am so tired. Have given up attempting to tack and have just locked the wheel again! Trouble is we're point east of north whereas if we were on the other tack I'd be pointing just south of west.

Will wait until weather settles down a bit. It's going to blow like the very devil in a minute when we get among these black clouds which I hoped to avoid. We are being literally blown sideways—every now and then there's a patch of ripply waves, a bit bumpy, and then a great wall of water comes marching down. A fearsome sight—sometimes beginning to curl at the top. Then you either shoot off the crest and crash down on the other side or settle gently over it as though on a rocking chair. Terrific one coming now with great streaks of white down its side, that banged the float a bit. This is the sort of occasion when you want someone with you just to share the experience. It would be nice sitting at home watching a television film of some idiot doing this sort of thing.

(Later) . . . the housing at the bottom of the supporting strut has broken free and

is moving in and out when we go over the waves. The situation is getting serious. When the gale subsides I am considering turning back to the Azores to get it repaired. They are 480 miles away—a better chance to get there than back to England. If we bump into any more gales, well, I just don't know. Will have to go very, very slowly—any big bumps are likely to pull the whole float right off.

1345 hours, Tuesday 15 June

I've been seriously considering my problem. I can't go on and must call somewhere soon. The float might break at any time, although I think I'll get good warning before it does, but my concern is what other strains and stresses are being imposed, and where! Still blowing Force 8–9 as it has for ages. It's heartbreaking to think that all the effort, trials and trouble that have gone into this project should be defeated by such constantly bad weather, which shows no sign of improving. This is June which should be summer time in these latitudes.

Have had a look at the Azores which is 480 miles to South-East which means I will be on the starboard tack instead of on port tack. As it is the port float that's out of the water and giving trouble, I'll stay upright as long as I'm on this tack even if it does happen to break off, but if I'm on the starboard tack then the weak float is under pressure and I'm not sure if it can take it all the time. So my alternative is to head for St John's, Newfoundland. This means facing the icebergs and fog of the Great Banks, *and* it's 900 miles. Again, I can go back to England which is some 1,300 miles. But then I would again be on the wrong tack which I must avoid while it's blowing.

I'm stuck with this problem and am still working it out. At the moment it looks like Newfoundland—840 miles to be exact. How long? 7–8 days? That's if the float holds and the weather becomes kind. But must go very slowly all the time—really cruising along, so I'm completely out of the competition; sickening, because I believe we were doing really well until this wretched trouble started.

1700 hours, evening of Tuesday 15 June

Still waiting for the sea to subside. If I try to sail a decent course other than due north, I'll have to go straight into the wind, over these big waves, which won't do the float any good. It was crashing over the waves that really caused the trouble. I feel absolutely empty inside and don't feel like eating when I realize I've got another week, if not longer, of this, listening to the float banging and wondering exactly when it's coming off! Haven't been able to contact anyone on the air to tell them about it but will try a contact at 1800 hrs. If unsuccessful, there's another guy running a ham radio station near the Royal Western, Plymouth. I'll contact him at 2000 hrs hopefully.

One of the real problems is that I'm not certain of my position. Have been out there three or four times trying for a sunsight and it's absolutely impossible. You never know whether the horizon is a wave and spray keeps covering everything so I've got to keep cleaning the lenses. It's very depressing indeed. If I make contact at 1800 hrs I'll get them to start a 4-hourly schedule just to check all's well. If the float does come off I expect we'll turn over—at present it's rattling and banging and setting my nerves on edge. I see my fibre-glassing has cracked again in one place. The rest of it's quite good and has helped to strengthen the whole thing. I don't think it's too bad. Lucky not to be going over any waves at the moment.

During a lull in the storm I went on deck to do a thorough inspection. The float is absolutely free—only the top part appears to be holding it on. Of course, just to cap everything, during my inspection I noticed that the housing round the other support on the starboard float is showing signs of a crack. . . . (later) . . . During a lull we changed course for Newfoundland but quickly found that taking these huge seas on the beam was even worse and the damaged float supports started working even harder. Knowing that the course to the Azores would have exactly the same effect, I continued to bear away until we were heading on a course for England, running dead before the wind with a tiny main and the storm jib set. What a relief! I can now go on deck without being covered with water and, going as we are, there appears to be little pressure on the floats even though it's still blowing Force 8.

2030 hours, Tuesday 15 June

I sighted a ship just now. Although I have been keeping a good lookout since we turned round, I did not see her until she was about 50 yards from me. She was completely hidden when in a trough and was really only visible when we were both on the top of a wave at the same time. I put up the signal flags K9 requesting her to speak to me on channel 16 VHF. We had a long chat and she offered to take me off but I declined. As she sailed away I felt even more alone and wondered whether I had made the right decision. She confirmed our position which showed that the storm had carried us 65 miles North-East of my Dead Reckoning position.

We eventually made landfall at Bishop's Rock Lighthouse in the early hours of 22 June after an incredibly fast run averaging 160 NM per day. We survived one more gale but because we were running downwind the pressure on the float was reduced and no further damage occurred.

Arrived at Plymouth in thick fog on 23 June.

Laboratory Wharf

STRE (MALTA)

INTRODUCTION

SPECIALIST TEAM ROYAL ENGINEERS (MALTA) has for some years had responsibility for overseeing the construction of new berths at Laboratory Wharf, a deep water quay on Grand Harbour, Malta. The original wharf was built many years ago to meet the needs of the Royal Navy, being located adjacent to several magazines and stores, many of which were in tunnels in the steep cliff rising up behind the harbour. There was also in the vicinity an underground ammunition laboratory from which the wharf took its name.

Development plans for facilities within Grand Harbour include the provision of more deep water berths and dry docks for the building and repair of bulk carriers of up to 300,000DWT. Appropriate facilities are also needed to meet the rapidly developing proportion of cargo shipped and transhipped in both containers and Ro-Ro (Roll on—Roll off) vehicles.

Malta's largest dry dock is being built not far from Laboratory Wharf on a site inshore of Parlatorio and Canteen wharves; these two latter wharves were until June 1975 still in use by the Royal Navy, who had loading and offloading lines there for various oil fuels. The Anglo-Maltese Military Facilities Agreement of 1972 provided that suitable alternative alongside facilities would be made available to the Royal Navy as replacements for Parlatorio and Canteen wharves, when these became unusable because of progress on the construction of the new dry dock. This dock, known locally as Red China Dock, is being financed by a large loan from the People's Republic of China, and built under the supervision of a team of engineers and technicians from that country. There would have been considerable difficulties for the Malta Government, both politically and economically, if work on the prestige dry dock project had had to be delayed because the original berths could not be given up.

The initial requirement for an improved Laboratory Wharf was that it should provide the alternative facilities needed by the Royal Navy. At first it was thought the wharf would, when not needed by the Navy, be used as just another alongside berth for general cargo. However, as overall plans for the Harbour were developed, it was decided in December 1975 to make it the main terminal for container traffic, and to provide an adjacent wharf at right angles to it for Ro-Ro vessels; with the right angle arrangement a Ro-Ro ship berthed alongside either wharf can be loaded from or discharged onto the end of the adjacent wharf.

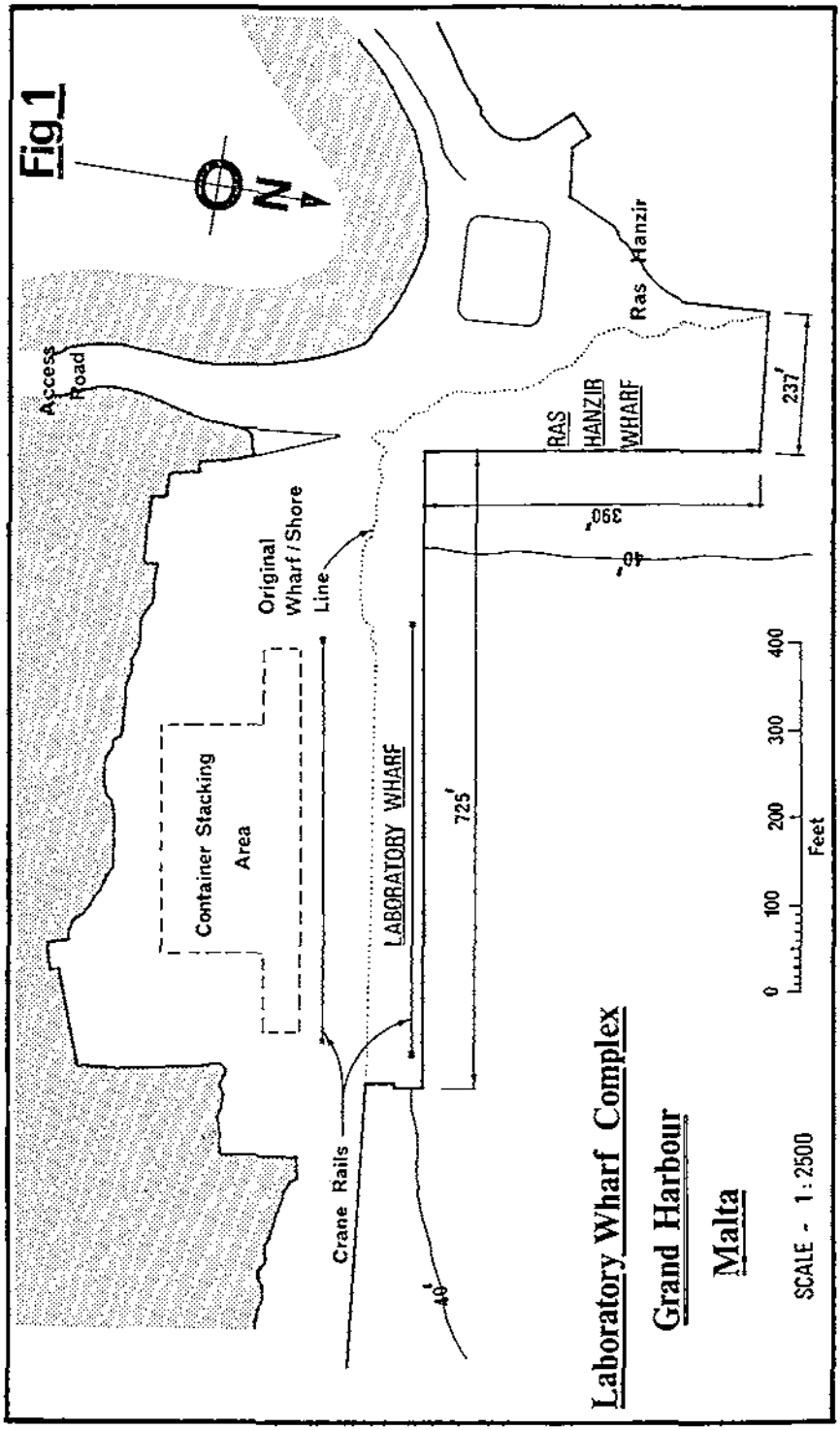


Fig 1
N
Access Road
Container Stacking Area
Original Wharf / Shore Line
LABORATORY WHARF
725'
Crane Rails
40'
RAS HANZIR WHARF
390'
40'
237'
Ras Hanzir
0 100 200 300 400
Feet
SCALE - 1:2500
Laboratory Wharf Complex
Grand Harbour
Malta

The original Laboratory Wharf was a mass concrete and masonry gravity structure some 600ft long; it had been badly damaged by bombs over about 100ft of its length but was otherwise in reasonable condition. The depth of water alongside averaged only about 20ft, compared with the 40ft considered necessary for the largest ships likely to use the new facilities. The harbour bottom was of rock, sloping rapidly downwards to an area previously dredged to take a floating dock; mud, clay and silt overlaid the rock. The only practical means of obtaining the greater depth of water was to build a completely new structure further out into the harbour.

Fig 1 is a plan showing the proposed final arrangement of the area. It is hoped that the majority of this will have been completed by the time that STRE (Malta) eventually disbands. Laboratory Wharf itself has a minimum alongside depth of 40ft for most of its length whilst the depth elsewhere is a minimum of 25ft, quite sufficient for the majority of freighters plying the Mediterranean.

The development is being carried out for the Ports Department of the Ministry of Finance, Customs and Ports. The responsibility for the works is that of the Minister of Public Building and Works, delegated through the Director of Public Works to the Chief Engineer Marine Works. The PWD had started construction work on the wharf early in 1972. When the STRE returned to Malta in late 1972, after the temporary withdrawal of British Forces from the Island, the Malta Government particularly asked that the Team should help to supervise this project. At first this assistance was limited to providing a Clerk of Works on site, but more was obviously necessary, and since about mid 1973 all the design, planning and site supervision has become the Team's responsibility, though still on behalf of the Chief Engineer Marine Works.

The basic design being used by the PWD at the time of the STRE's arrival on the project had been adapted from local experience and custom as being the most suitable for conditions in Malta, taking account of the lack of skilled labour, the shortage of modern plant and the requirement to limit the use of imported material such as steel reinforcement and beams; it has nevertheless been modified to some extent to allow for variations in the depth to rock and to give improved stability. The design was further amended in two sections to take account of some earlier construction where remedial work was considered necessary to meet the expected loading conditions.

AIM

The method of construction of the wharf wall has advantages of simplicity and economy of plant which might be of value in a military setting. In addition, there are some local practices which are well worthy of note. The aim of this article is therefore to describe for future reference the method of construction and the lessons learnt.

DESIGN

(*All measurements are given in Imperial Units since these remain in current use in Malta*).

The new wharf is a mass concrete gravity retaining wall. The typical cross-section for the deep water areas is shown at Fig 2; the cross-section of the upper parts of the wall remains the same for all depths to bedrock, whilst the lower parts are omitted when satisfactory foundation can be provided on the rock at lesser depths.

The loadings considered included a superimposed surface load of 5cwt/sq ft, horizontal and vertical reactions from the front crane rail, horizontal bollard pull, hydraulic loading from differences of water level behind and in front of the wall and active pressure from the rock fill. The worst possible combination of such loads was taken, although in practice it is most unlikely that all could act concurrently. Allowance was made for the effect of friction between the fill and the rear face of the wall in helping to resist overturning. It was confirmed that the resultant load at all

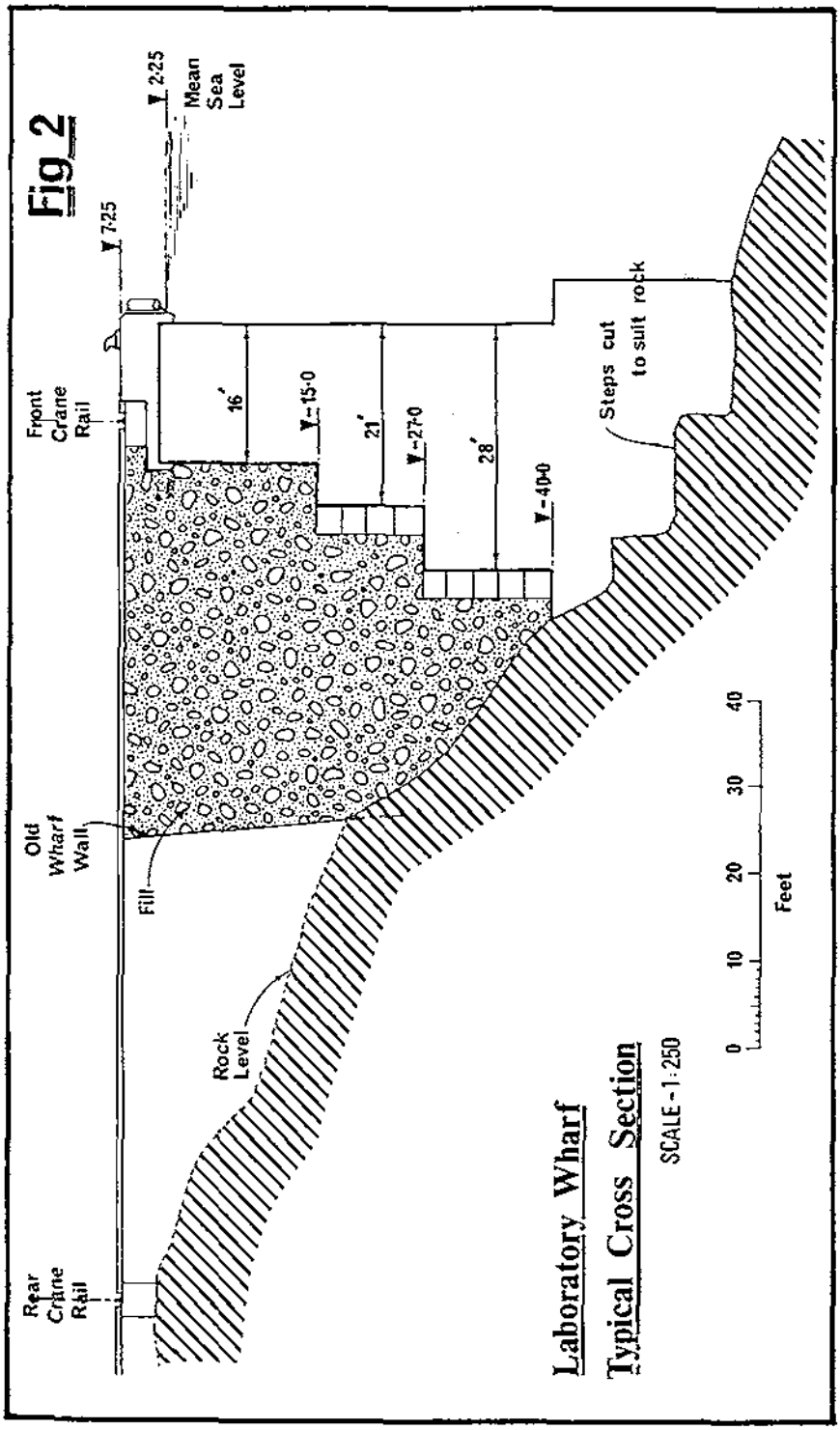


Fig 2
Mean Sea Level
Y 2·25
Y 7·25
Front Crane Rail
16'
Y-15·0
21'
Y-27·0
28'
Y-40·0
Steps cut to suit rock
Old Wharf Wall
Fill
Rock Level
Rear Crane Rail
Laboratory Wharf
Typical Cross Section
SCALE - 1·250
0
10
20
30
40
Feet

levels would act within the middle third of the wall width as required by the Code of Practice, thus preventing any tension within the concrete or between the concrete and the rock on which it is founded. The Factor of Safety against overturning was checked and found to be in excess of 2·5 at all levels. The maximum pressure between concrete and rock is nowhere greater than 75lb/sq in (4·8 tons/sq ft), which is well within the bearing capacity of the Globigerina limestone present as bedrock.

The wall is built in elements varying between 20 and 50ft in length. A reinforced capping section ties the elements together above water level so that they act monolithically in resisting horizontal point loads such as those from bollards and the gantry crane.

CONSTRUCTION

Construction Sequence

Work on the gravity wall follows the logical sequence of excavation, inspection, placing of formwork, and underwater concreting; after this there is construction of the above-water capping including the fixing of bollards, filling behind the wall, compaction, laying of drainage and surfacing; final tasks include the installation of fenders and crane rails.

Access for construction of the wall elements is achieved by building out mass concrete arms from the old quay, founded on rock, and at about 100ft centres; greater spacings, up to 150ft, were used in early stages. These arms are made 16ft wide, sufficient to take excavators and ready-mix trucks. Once each arm has been built out to the line of the new face, construction of wall elements can take place in both directions from the end.

Excavation

The purpose of the excavation is twofold. Firstly, to remove all mud, clay, soft and weathered rock, thus providing a firm surface on which the wall can be built up. Secondly, to provide a suitably shaped rock profile to resist any tendency of the wall elements to slide outwards and downwards. The soft material is removed relatively easily using an ordinary grab fitted to an excavator. The excavators, which are tracked, are mostly of World War II vintage and are cable operated. Some of the grabs have tines fitted, some have not; there has been no noticeable difference in performance one way or the other; most have capacities of about ¾cu yd.

The water in Grand Harbour is never very clear, and rapidly becomes cloudy once excavation is in progress; the work cannot therefore be controlled visually from the surface. The excavator operators are taught to vary their area of attack continually within a given area, usually indicated by markers fixed above water level. The depth to which they should work is shown by string or cloth tell-tales attached to the grab ropes. Luckily there is virtually no tide in Grand Harbour, and although the water level does vary with the wind and other conditions, it never changes by more than a few inches in any one shift.

The mud and clay are excavated from an area about 5ft beyond that in which construction is to take place; this reduces the risk of their falling back into the excavation. Excavating into the area required for the subsequent wall element ensures there is no need to work close to, and risk damaging the base of, work already completed.

The initial surface rock can usually be removed straight-away by grab, but lower layers which are still relatively soft must first be broken up. The use of explosives has been considered inadvisable, particularly during the later stages of work when there have been full fuel lines within about 100ft. Various forms of chisel have therefore been used, suspended from an excavator and dropped freely through the water to strike the rock and break it up. These chisels are illustrated in Photo 1. The first pattern (top) is a piece of thick steel plate weighing about 4 tons; it has a hard-faced cutting edge. This has been found to work well on soft rock, but it tends to slide off harder rock instead of digging into it; it also has a tendency to become jammed in fissures and crevices. The second pattern (bottom), or "applecorer" as it has become

known, is much more effective in breaking up hard rock; it weighs about 3½ tons and also has a hard-faced cutting edge. By repeated dropping of the chisel on to the rock, the surface is gradually broken into pieces easily excavated by grab. It is usual to chisel an area for about four or five hours and then to replace the chisel with a grab to remove the spoil. It has been found that the best results are obtained when

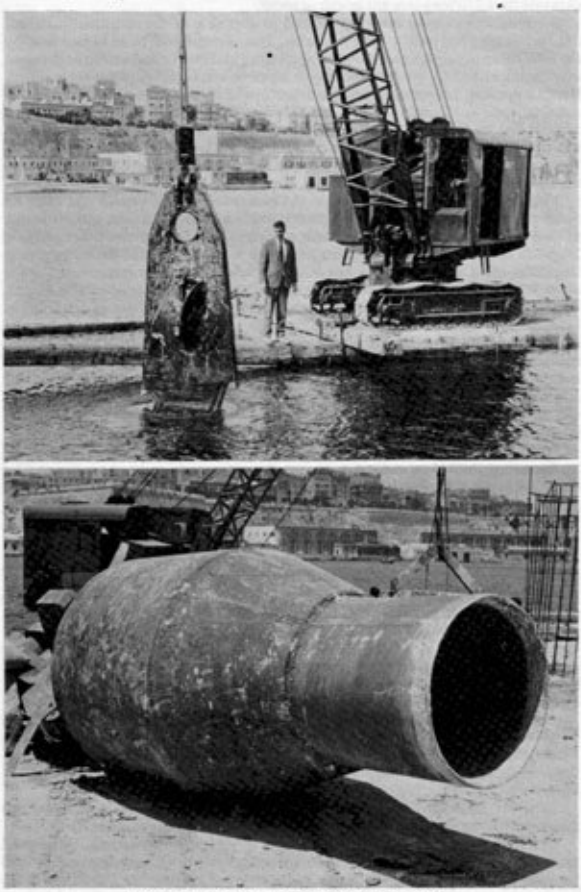


Photo 1. Chisels for underwater rock excavation.

Laboratory Wharf 1

dropping the chisel from about 10ft above bottom level; if it is dropped from a greater height, it takes longer to raise each time, but there is little difference in the degree of penetration effected. Excavation obviously takes longer in deeper water, because of the extra time in raising and lowering the grab. As a rough guide, using one excavator for both chiselling and grabbing, it takes about 15 working days (of 8 hours each) to excavate for a 25ft long element in 45ft of water.

Some difficulties have been experienced in disposing of the excavated material; double handling has usually been inevitable. The owners of the hired tippers used by the PWD are not prepared to allow wet spoil straight from the harbour to be dropped into the tipper bodies—understandably so, since no additional payment is permitted. Bottom opening barges or lighters are not available. At times, if the material is suitable, spoil is dropped directly as fill behind the wall when this can be done without risk of falling back into areas of current or future excavation. Sometimes spoil is placed on deck slabs already constructed and left to dry out before removal. More usually it is dropped directly into the harbour from the grab, as far out into deep water as possible; later, if necessary, it is removed by dredger.

Final clearing of small stones from the excavation area is carried out using an airlift pump. The suction unit of the pump, which is little more than a short length of steel pipe with an air pipe and nozzle welded to it, is fitted to the lower end of a length of 6in diameter flexible rubber hose; this hose which is the discharge pipe is suspended from an excavator. A line from a 315cfm compressor is connected to the air pipe so that compressed air is directed to escape inside the suction unit and pass up the discharge hose. This has the effect of decreasing the density of water in the hose, creating a pressure differential at the bottom sufficient to draw in both water and solids. The upper end of the hose is positioned so that it discharges freely into the harbour away from the area being cleared. The suction unit is moved around the bottom with the aid of the excavator, keeping it a few inches off the rock. The effectiveness of the airlift pump increases with depth of water; at about 8ft depth it will move little more than fines; at 20ft it will suck up particles of about 1in diameter whilst at 40ft depth stones up to about 3in diameter can be removed.

Inspection and Control

Soundings are taken every day or two during excavation to show the profiles being obtained and to allow any necessary corrections. The soundings are on a 5ft grid, based on markers accurately set up above water level around the section being prepared.

When the soundings indicate a suitable finished profile and when the material being brought up by the grab is limited to small pieces of rock with reasonably clean (and therefore newly cut) faces, probe tests are carried out to determine the soundness of the exposed rock. A long steel beam weighing 1¾ tons and with a square cut end is dropped freely from about 5ft above bottom level to strike the rock. The penetration is measured; anything under 4in is acceptable though penetrations of 2in are common. Rebounds with a high pitched sound occur on the best rock. Divers are then sent down to inspect the surface to find out if there are any remaining high spots; this crucial inspection is always carried out by RE divers.

Survey work is carried out in the normal way from a number of reference monuments and bench marks established around the site. Soundings were taken over a wide area during early stages of construction and before planning the subsidiary berths; these, with standard above-ground survey, provided the basis for an up-to-date site plan on which the layout of new works was then designed.

Formwork

Different methods of forming the concrete for the underwater elements are employed for the front and rear faces and for the faces between adjacent elements.

The front faces have precast concrete slabs as permanent formwork. Heavy steel beams are first dropped to stick into the underlying rock and are then braced together at the top by timber baulks and a series of clamps; the beams are at 8ft spacing, corresponding to the length of the precast slabs. The slabs, 3in thick, have

reinforcement stirrups exposed on their rear faces; two ¼in diameter bars are welded to the stirrups at both ends of each slab and bent forward so that all four bar ends protrude about 6in in front of the slab face. The units are lowered individually by crane and set in place by divers; the protruding bars are then bent around the flanges of the vertical steel beams to hold the slabs fast. Above the minus 40ft level the front face of the wall is 5ft further back than it is lower down (see Fig 2). Additional steel beams to support the formwork panels for the front face above this level are dropped and penetrate a short way into the green concrete to provide horizontal resistance; any damage caused in the process is not significant.

The lower rear faces are formed using precast concrete blocks, 3ft × 3ft × 6ft, placed beside or on top of each other as required and positioned by divers and crane. Some of these blocks are recovered for re-use, but those not easily moved are left in place and become part of the fill. The section of the rear face above 27ft is formed using sheet piles.

Between elements, a shear key is formed in the concrete using large Appleby Frodingham sheet piles on the higher levels and prefabricated sheet pile panels at lower levels, supported again by vertical beams; the adjacent element is later poured directly against the face of the previous one.

The height of lift of concrete is normally restricted to less than 10ft, the limitation being the amount of concrete which can be delivered in a day. This also reduces the forces acting on the formwork. However, the area being concreted is usually so large that the rate of rise is low, and the first concrete poured has set before the lift is completed. Further, as everything is under water, the effective density of the wet concrete is much less than above the surface.

Concrete bagwork is placed by divers to fill any voids below the initial front slabs and between forms.

An interesting and effective method is used for holding the sheet piles in position. Individual piles are coupled together and lowered into position to rest with their bottom edges on the rock or concrete below. At the top there are the previously mentioned timber baulks which restrain the piling from moving outwards. There is however a strong tendency for it to be moved inwards by wave action, especially from passing vessels. Holes are therefore drilled in the top of each pile and large S shaped hooks (about 12in overall) are inserted. Cylindrical concrete blocks weighing about 3cwt each, formed in the ends of 40gal drums and with cast-in loops, are then connected up using additional hooks, so that they hold the sheet piles downwards and firmly against the baulks. These can be seen in the view at Photo 2.

The standard finish achieved below water level is of no great significance, and the formwork is consequently somewhat rough and ready. It is nevertheless effective. A positional tolerance of 6in is accepted for the underwater work, but the wall thickness must not be less than the dimensions specified.

The steel sheet piling and the vertical beams are removed the day after finishing each element. No release agents are needed since a thin layer of laitance tends to form against the sheeting. The penetration of the beams into the rock and concrete is only a few inches yet the lateral resistance from their weight is adequate to provide the necessary support. To reduce the risk of formwork being disturbed by wave action prior to concreting, panels are normally only erected sufficient for the next immediate pour.

Concrete Placing

All underwater concrete is placed by bottom opening skip; this method is more flexible than tremie for covering relatively wide areas, and allows for the risk of delays in the supply of concrete. The concrete, which is a special underwater grade, designed by the Team's CLO, has a minimum cement content of 550lb/cu yd; it is delivered in 8, 10 and 12cu yd truck mixers from a Ready-Mix supplier near Mosta, some 9 miles from the site; a slump of at least 5in is specified, to ensure free flow; the minimum 28-day cube strength required is 3000lb/sq in.

The skips are filled directly from the mixer trucks and canvas flaps, fastened to the

Photo 2. Arrangement of formwork.

sides of the skips, are folded over to cover the wet concrete. The skips are then lowered to the position required, where they are opened and the concrete is allowed to flow out freely. The crane operators lifting and lowering the skips are supervised carefully to ensure the skips are not lowered too fast through the water, and that the skips are not opened until slack in the cable shows them to be resting on the bottom or within previously poured concrete; in these ways the contact and mixing of wet concrete and sea water is reduced to a minimum.

Soundings are taken from time to time to check that the concrete is being placed correctly, but continual checks are carried out by the crane operators comparing tell-tales on the hoist ropes with the water level as each load is lowered. To provide full resistance against possible sliding, it is always arranged that the upper surface of concrete, and thus also of finished lifts, slopes slightly downward from front to rear.

Some laitance is bound to occur on the top surface of the concrete, from cement being leached out. This is removed by airlift about twelve hours after concreting, normally first thing the next morning.

The maximum concrete pour on any one day has been 1,003cu yd; this was in a

Laboratory Wharf 2

sheltered remedial works area where there was no restriction on lift height due to formwork. Special arrangements were made with the concrete supplier for him to concentrate all his resources to the one project. Pours are usually of about 300cu yd, at a rate of around 35cu yd/hr.

The underwater elements are roughly levelled off at about 1ft above water level to provide a dry working area for further construction.

Capping

The capping is 6ft deep, constructed in two lifts. Its upper edge forms part of the wharf dock surface, whilst the bottom is about 1ft below mean sea level. Because of the difficulty of producing a good concrete finish and dense concrete around reinforcement underwater, the outer edges of the lower lift are formed with pre-cast beams. These beams, together with connecting reinforcement added in situ, are designed to tie together the underwater concrete elements and spread the loading from the 50 ton bollards. The front beam is first positioned on steel hanger brackets fixed to the main concrete elements, whilst the rear unit is placed on hardcore suitably levelled off and resting on rock fill beneath. The uneven spaces between the front units and the elements are sealed with plywood panels and sandbags as necessary. The beams are 43ft long and weigh 9 tons.

Once the beams have been positioned carefully to both line and level, steel reinforcement is laid between them above the elements, both longitudinally and transversely. End forms are shaped to provide trapezoidal shear keys. Concrete is then poured to give the lower lift. In due course the hanger brackets supporting the front beams are burnt off; it is considered that any corrosion products occurring behind the surface will soon swell and seal the concrete behind to restrict any inward spread of corrosion.

The upper layer of capping is placed well above water level within timber forms; this layer is unreinforced except where bollards are to be located.

Fill

The areas between the new and old walls are filled with rubble as a base for the new wharf apron. Most of the fill material is brought in by tippers from sites where rock excavation is in progress such as the Red China Dock; material from the demolition of old buildings adjacent to the wharf has also been used. Ideally, the fill should be well graded without large boulders. In practice it is usually necessary to use whatever is available for delivery to site, as there is little opportunity for sorting, and a general shortage of material compared with the many demands for it. The fill is tipped directly into the water, and no compaction is possible until the surface is well above water level; the largest boulders are then removed from the top layers.

The old harbour bottom on which the fill is placed is not dredged, so that whatever mud there is must remain; this may later result in some settlement; but the consequences are not considered serious, especially since there may also be some settlement within the freely tipped fill. Although the new wall should be watertight, the old wall is probably not so and the underlying rock is undoubtedly fissured. It would not therefore be possible to dewater the area between the old and new quay walls to allow work in the dry without considerable grouting and strengthening of the new wall itself—this is not justified.

Above water level the fill is compacted as well as can be managed with the limited availability of suitable plant. Some initial compaction is achieved from the wheels of tippers bringing in further fill; this is then improved using a dozer to spread and consolidate the top layers. A small vibrating roller is then used if available.

Surfacing

Concrete slabs 9in thick are laid above the fill to suitable levels for drainage. The slabs are normally in bays 15ft wide, reinforced with steel fabric mesh. They are laid between side forms, and given a rough screeded finish. Steel beams were initially used as side forms; a crane was needed for lifting and placing them, so that delays frequently occurred; furthermore, there was a tendency for the beams to get bent and they could not easily be straightened. More recently "franka" masonry blocks,

the local yellow limestone building material, have been used; these are quickly placed to the correct line and level by local masons; they are sufficiently solid to give the required restraint, so that their use has been adjudged the best method for local conditions. These franka blocks have also been used as formwork on other parts of the project; they are easily worked to almost any shape required. Careful curing using wetted tarpaulins is necessary, especially in summer. Some cracking of the slabs will probably occur in time as the fill settles below them, but this is not likely to have any serious repercussion since the main purpose is to provide a firm clear area for stacking containers, and for the movement of vehicles.

Drainage

As mentioned above, the rock below the fill is fissured, and it is found that the water level within the fill is seldom more than a few inches different from that in the harbour. A french drain is however provided behind the wall just above sea water level, with discharge pipes into the harbour to prevent the backup of water behind the wall; no discharge has ever been noticed from these pipes, although the wall design allows for the water level to rise to them with the harbour level being at its minimum.

The level of the old wharf was slightly lower than that of the new one. The quay surface of Laboratory Wharf was therefore arranged to slope gradually down behind the face to provide a reasonably flat working surface or apron. Gulley traps with drains connecting forward are provided to remove rainfall. On the nearby Ras Hanzir wharves the levels will be arranged so that the surface behind the quay is higher, and that rainwater flows freely down over the edge. Soon after completion of the first part of Laboratory Wharf it was used for general cargo (including much bagged cement and fishmeal); at the same time, the road along the old wall was being heavily used by loaded tippers and the demolition of old buildings was in progress in the vicinity. There was thus considerable accumulation of loose material on the back of the wharf and every time it rained this was washed into the gulleys, one of which then became blocked. This suggests that this system of drainage should not normally be used where there is a risk of heavy spillage; it would perhaps have been better to have long channels with perforated covers running behind the quay, with large and more easily emptied silt traps instead of the normal street gulley traps.

Fenders

Tubular rubber fenders mounted on galvanized steel chains are fitted diagonally along the face of the wall. These will eventually give complete coverage, although as an interim measure, whilst awaiting authorisation to purchase, alternate fenders have been omitted, and those fitted are of a smaller size than specified, being spares left over from another project. Whilst the larger vessels using the wharf have almost vertical sides and seldom cause any damage, the smaller vessels have sloping sides near stem and stern and have caused some spalling of the capping when manoeuvering with insufficient care. The use of the correct number of fenders of the right size will minimize this damage, though superficial damage from small vessels cannot be ruled out without a much more costly and substantial fender system.

Labour

The workforce on site has varied to some extent, but that employed on the wharf has been generally as follows, supplied as direct labour by PWD:

Foreman	1
Gangers	2
Plant Operators	5
Welder	1
General labour (including some from quasi military organizations)	35
Draughtsman	1

In addition there have been two divers from the Armed Forces of Malta (Pioneer Corps), with extra divers on call from Malta Drydocks.

Problems have been experienced with absenteeism, which has tended to reduce the numbers by an average of 20%. On the other hand, permission was obtained for limited overtime, extending the normal local hours of work to include Saturday mornings and afternoon working in summer when Government employees normally cease work at midday. On occasions, seven-day week working has been necessary to meet important target dates.

Site supervision by STRE has included a Project Engineer, one (occasionally two) Clerk(s) of Works (Construction), a Diving Supervisor and a CLO (part-time). Engineer Surveyors have been available on call. Much of the Project Engineer's time has had to be spent in chasing around Government offices to obtain and maintain labour, plant and stores, and in liaison on future plans.

As any other Consultant organization, STRE has had to provide Head Office design effort in addition to its staff on site. The 21C who doubles as the Team's Civil Engineer (Design) has put in much time on planning the layout, designing crane rail foundations, and in dealing with the Ports Department and their Ministry (The Clients). He has been supported in this work by additional draughtsmen within the HQ.

Plant, Transport

The regular items of plant have been:—

Compressor	1
Excavators, tracked, rope operated	5
Shovel loaders, wheeled (LWT)	1
Welding set, electric, engine driven	1

A modern hydraulic excavator has also been available from time to time. Plant serviceability has averaged about 75%, maintenance being carried out on an as-required basis by a team from PWD workshops. The availability of spares has been poor, as might be expected considering the age of the equipment. Furthermore, the workshops have been loath to change such common items as batteries and wire ropes until completely worn out; this policy has undoubtedly decreased efficiency and led to a greater proportion of lost time from the equipment.

Hired tippers have been provided through PWD when needed, and it has sometimes been possible to borrow others, larger and more modern, from the Red China Dock project.

Timings, Planning

Construction timings have depended greatly on the excavation depth, the availability of labour and plant, etc. The sequence of construction must be irregular; fill can only take place when sufficient sections of wall elements have been built to seal off areas from the harbour; other works are then staggered in consequence. With access arms built out at approximately 100ft intervals, average conditions, and a water depth of 45 to 50ft, 100ft of quay should be completed from initial excavation within four to five months. For the shallower Ras Hanzir wharf construction (water depth 25 to 30ft), it is expected to achieve approximately 600ft in about twelve months.

Cascade techniques have been used extensively and most successfully in the preparation of construction programmes. Planning has however been complicated to some extent by delays in getting Government approval of future works and by political requirements to meet certain deadlines on timings.

Costs

STRE have not been given responsibility for any of the project costings other than for preparing occasional advance estimates. It is considered that the costing systems used by the PWD have been somewhat artificial, since many items are omitted or treated separately. Ready-mixed concrete is delivered to site at about £9 per cu yd. Plant costs are of the order of £1,000 per week. Labour rates average £20 per man per week. On this basis, for a wall founded at 45ft, the approximate cost is £900 per foot run, inclusive of a 10% allowance for miscellaneous temporary materials, fenders etc, but excluding the gantry container crane, its rails and their foundations.

Photo 3. Laboratory Wharf nearing completion, June 1976.

For a 25ft depth the cost comes down to about £500. These costs are in sterling, based on an exchange rate of £1 Maltese equating to £1·30 sterling.

CONCLUSION

The gravity wharf construction is not cheap, nor particularly quick to execute, but it is simple and requires only basic skills and commonly available equipment. The extent of supervision needed depends upon the skill and reliability of the labour force. Whilst the supervision is undoubtedly less than for modern sophisticated forms of construction, it is most important to ensure that the preparation of the foundations, the erection of formwork and the placing of underwater concrete are correctly carried out; this needs skilled and responsible supervision, some of it by fully trained divers. A view of the wharf nearing completion is given at Photo 3.

Acknowledgement
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"Projected Image Target System"

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LANCE CORPORAL R BELL, RE

INTRODUCTION

THE low standard of marksmanship of the "soldier of the seventies" is a matter of some concern throughout the Army. The "Shoot to Kill" concept is one method to combat this failing; another is the "Projected Image Target System" which basically allows the firer to select a target on a cinema-type screen on an indoor range. The

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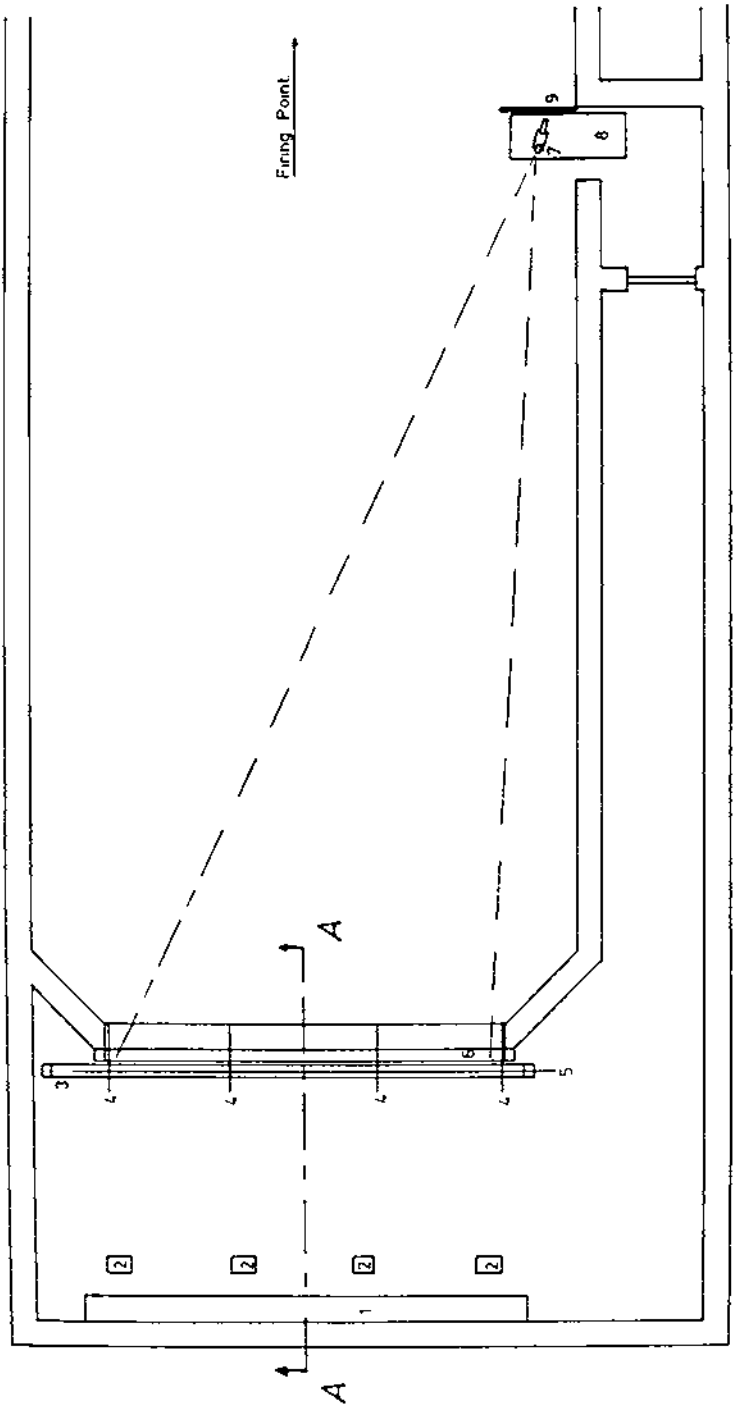

Fig 1. Plan of Range Layout. **Legend:** 1—Baffle plates, 2—Floodlamps, 3—Rear Screen, 4—Trackway Supports, 5—Trackway, 6—Front Screen, 7—Projector, 8—Projector table and 9—Door.

films depict a number of realistic operational situations with which the soldier may be faced. Unfortunately, 39 Engineer Regiment (Airfields) did not qualify for the issue of this equipment so the Commanding Officer ordered that a study be made to ascertain whether it was possible to build such a system using unit self-help. The results were encouraging and this article describes how the system, now in use at Waterbeach, was constructed. It is suggested that other units could use this information as the basis for similar projects of their own.

METHOD OF CONSTRUCTION

This was predominantly a matter of trial and error; in contrast to normal Engineer projects with convenient drawings and stores lists, the task was completed from sketches on the backs of envelopes and occasionally, inspired guesswork. Costs had to be minimal and, in retrospect, the essential quality of those involved was, what LCpl Bell aptly described as, "self-help yourself"; this gave rise to numerous telephone calls from aggrieved storemen.

METHOD OF OPERATION

In order to understand the construction of this system, it is necessary to outline the principles of operation; these are:

(a) Firer identifies the target on the screen and pulls the trigger.

(b) The bullet passes through two screens, a front and a rear.

(c) On passing through the screens the bullet hits a baffle plate at the end of the range (see Fig 1).

(d) A trembler switch on the baffle plate detects the vibration of the bullet impact and transmits a signal to the control unit.

(e) The control unit then operates a relay which stops the projector thereby freezing the action.

(f) Light from the floodlights situated behind the rear screen (see Fig 2), penetrates the bullet holes through the screens and the firer thus sees a pinpoint of light where his shot has actually hit the target.

(g) The control unit allows the firer a period of time for observation.

(h) The control unit then operates a relay to supply the rear screen drive motor with current which moves the screen about 5mm along the trackway (see Fig 3). Light from the floodlights is thus prevented from reaching the firer and the pinpoint of light disappears.

(j) As soon as the rear screen movement has stopped, the control unit operates a relay which starts the projector and the film continues.

(k) This sequence is repeated for successive shots.

(l) When using the Carl Gustav and sub-calibre device which enables 6·5mm indoor rounds to be fired, the time of the flight of the round can be simulated by the control unit. The time elapsing between the impact of the round and the projector stopping can be varied from 0 to 5 seconds. This means that the firer must aim off correctly to score hits on moving targets.

CONSTRUCTION

After a number of failures the following system was adopted:

(a) *Front Screen.* A wooden braced frame covered with hessian had white target paper pasted onto the surface for the projected image of the film.

(b) *Rear Screen.* This was similarly constructed but was hung on a trackway (see Figs 2 and 3).

(c) *Screen Covering.* It was quite clear that the distance between the front and rear screens should be minimal, in this way the horizontal movement of the rear screen after each shot was reduced to a minimum. The coverings were fitted as follows:

(1) *Front Screen.* The hessian covering was fitted to the rear edge of the frame.

(2) *Rear Screen.* The hessian covering was fitted to the front edge of the frame.

(d) *Rear Screen Trackway.* As shown in Figs 2 and 4 a trackway was suspended

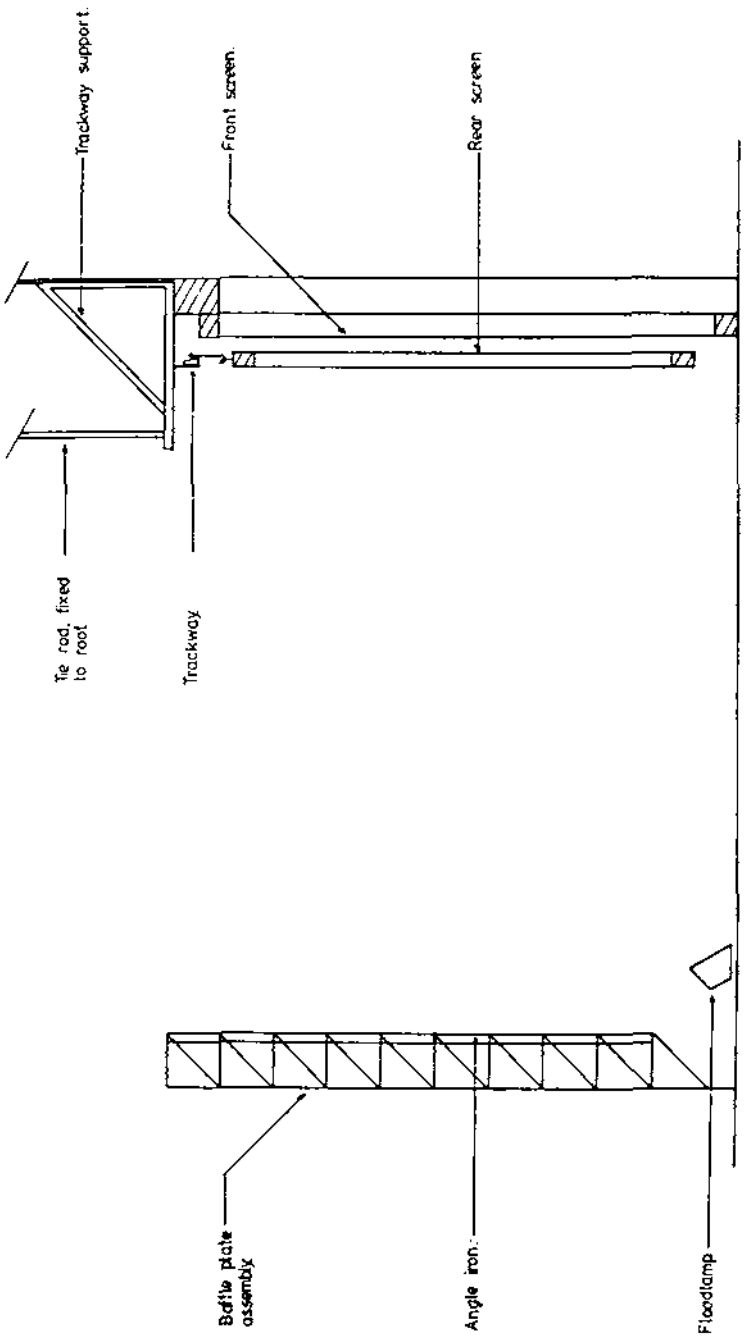

Fig 2. Sectional View of Screens.

Projected Image Target System 3

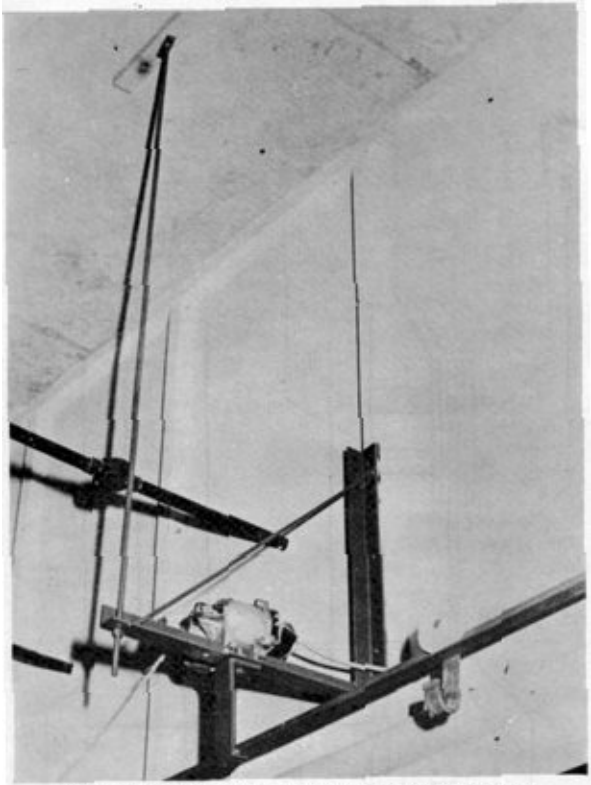

Fig 4. Method of fixing rear switch trackway from roof and wall of range.

electrician with some practical assistance from Pye of Cambridge. The circuit diagram is shown in Fig 6, and the components are listed in Table 1.

Range Layout

This is shown in Figs 1 and 2. The projector is at an angle to the screen and is protected from stray shots by a 12mm steel plate fixed to the door. Similarly the floodlights are protected from low shots by steel quadrants 300mm high which are standard issue for indoor ranges.

Films

The complete list of films issued to Cine Target Training Theatres can be found in Section 26 of the Army Film Catalogue Code No 70477 Part 1 1974.

Projected Image Target System 4

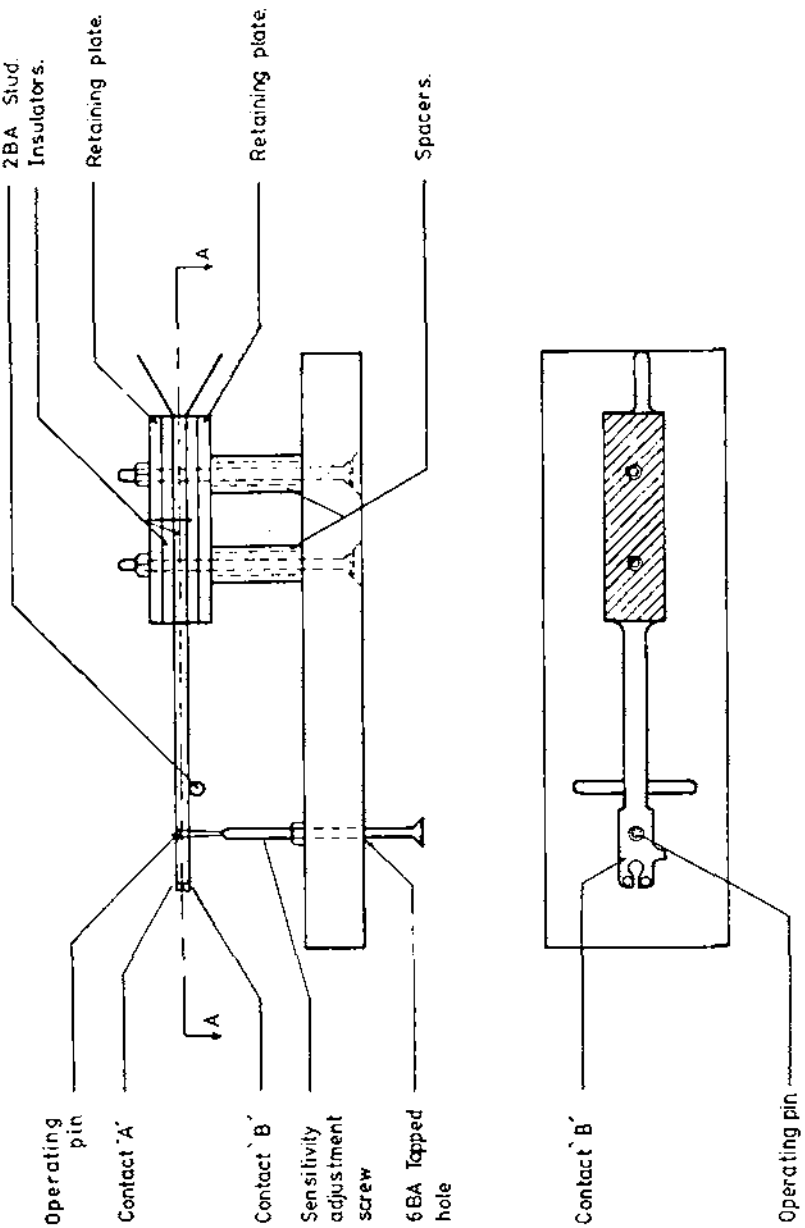

Fig 5. Trembler switch made from normally closed relay.

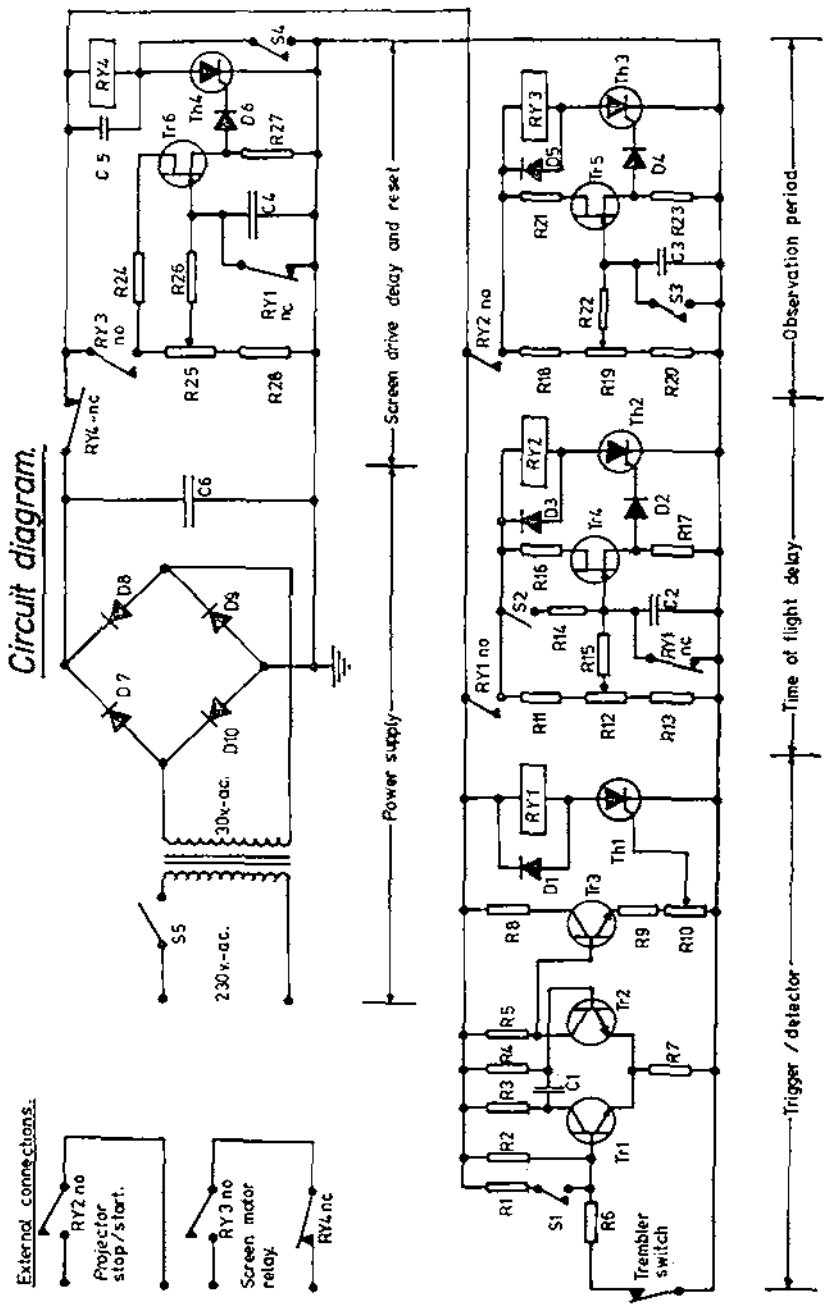

Fig 6. Control Unit circuit diagram.

USE OF RANGE

A detail of four firers is possible but two would be more suitable. The coach must stand directly behind the firer in order to observe the pinpoint of light or he will not see the strike of the shot. The control unit can override the sequence of relay operation so that the time for observation can be extended indefinitely, in this way the coach or NCOIC can correct faults as they occur at the firing point.

After approximately two hours normal use both screens will require pasting up. The front screen should be patched with white paper and white emulsion. The rear screen merely requires patching and, as previously described, may need resetting.

CONCLUSION

The system took over a year to perfect; however it is now in regular use at Waterbeach and is a good example of what a talented and determined JNCO can achieve demonstrating traditional Sapper qualities of initiative and ingenuity. Apart from the projector and film, the total cost of our system was under £50, a fraction of the cost of the issued system and certainly it is technically superior—at least in the eyes of the designers!

Table 1. Control Unit Component List

R1	15,000 ohms		R15	100,000 ohms	
R2	27,000 ohms		R16	15,000 ohms	
R3	4,700 ohms		R17	470 ohms	
R4	4,700 ohms		R18	3,300 ohms	
R5	39,000 ohms		R19	22,000 ohms	potentiometer
R6	3,300 ohms		R20	4,700 ohms	
R7	470 ohms		R21	15,000 ohms	
R8	3,300 ohms		R22	330,000 ohms	
R9	470 ohms		R23	470 ohms	
R10	470 ohms	potentiometer	R24	15,000 ohms	
R11	470 ohms		R25	22,000 ohms	potentiometer
R12	30,000 ohms	potentiometer	R26	100,000 ohms	
R13	6,800 ohms		R27	470 ohms	
R14	4,700 ohms		R28	4,700 ohms	

C1 1 mF
C2, C3 and C4 15 mF (solid tantalum electrolytics)
C5 500 mF
C6 220 mF

Tr1, 2 and 3—BC 107

Tr4, 5 and 6—2N2646

Th1, 2, 3 and 4—BTX 30/25

D1, 2 and 3—BY 134
D4, 5 and 6—2N4148

D7, 8, 9 and 10—1N4006

S1 Test push button (a normally open push button)
S2 Time of flight IN/OUT switch (STSP switch)
S3 Hold push button (a normally open push button)
S4 Cancel push button (a normally open push button)
S5 ON/OFF switch (STSP switch)

RY1, 2, 3 and 4—make TMC No GPR 300

All resistors are ¼ watt 10% unless otherwise specified
A 2 amp fuse (not shown on circuit diagram) was positioned between the ON/OFF switch and the transformer.

The complete circuit with its relay was mounted on a printed circuit board measuring approximately 150 × 150mm.

* * *

Serving my Time

LEARNING ENGINEERING IN LOCAL GOVERNMENT, THE ARMY AND POSTWAR PARIS

COLONEL A J HARRIS, CBE, B Sc, C Eng, FI Struct E, M Cons E
(Engineer and Railway Staff Corps T & AVR. Professor of Concrete Structures, Imperial College; Senior Partner Harris and Sutherland)

How does one become an engineer? Teaching? Experience? The laying on of hands? Would that I knew. As a successful civil engineer (and by successful I mean a civil engineer who has succeeded in getting something built—no small achievement), and as a Professor charged with teaching the young I ought to know. I can indeed trace my own path and identify two major influences, my war time years in the Army and my stay in France with Freyssinet, but the conclusion is unprofitable, since it should not be necessary to start a war and Freyssinet, alas, is dead. But the story might throw light on engineering, military and civil, and the relations between them; between as it were, the father and the son.

Local Government 1933–40

There are statements about one's schooling which are introduced by the phrase "You see at the time my father . . ."

A dockyard-trained electrical engineer in the Admiralty between the wars was not well paid and I was the eldest son. There was talk of my sitting for a Cambridge scholarship but since the extra year at school would surely have been devoted to chess and football, I have no illusions of being deprived when at seventeen my father got me a job at the Borough Engineer's Office at Hendon and I started to study for my degree at night school.

I was a "junior under agreement". The title represents the first drift away from the articled pupil system, then falling into disrepute. To share an office with and follow the working day of an eminent engineer is a rare privilege and one worth paying for, but too many pupils were treated as no more than trainee draughtsmen, no different from me, and their parents paid good money for nothing.

To start work in a drawing office with a batch of men mostly a touch on the common side and incredibly old (one, whose omniscience was discouraging, I have often met since—he must have been twenty-four at the time) was a shock after the ease, the culture, the privilege of the sixth form—and what a bore to work at the same thing from nine to five! I spent five evenings a week at Northampton Poly (now the City University); more, I had to give up football since we spent Saturday afternoons surveying on Hampstead Heath—a pointless exercise because I was soon engaged on far more complex surveying most days of the week.

This went on for three years. I daydreamed my way around the streets of the Borough with theodolite, level and staff, began to be a competent draughtsman and plodded through syllabus and course work for my degree. Engineering interested me hardly at all, to tell the truth, for I was consumed with a burning interest in matters which I still think more important and I am surprised in retrospect at the breadth of my reading in those overloaded years. I passed my degree with the modest distinction of a good second, while still nineteen (just). The only value I can detect of that degree is that I have never had to worry about not having one; nothing which we were taught, other than the most rudimentary Theory of Structures, seems to have been of any value since. But there, think of the novelties since those days of which one has been obliged to pick up some smattering—relaxation methods, plastic design, limit state design, prestressing, soil mechanics, shell theory, finite elements and all the analytical developments which came with computers, to name but a few.

More important, I had begun to build up a zest for doing a survey expeditiously and well, one which closed with adequate accuracy, required no revisiting the site

and was plotted fast—one developed ways of tricking oneself into maintaining concentration. High standards of draughtsmanship were demanded in the office; I had come to admire the works of Eric Gill and on my drawings sought to reproduce the letter forms of his type fount "Gill Sans", admirably based as it is on the search for maximum clarity. At long last, I became a tolerable draughtsman, though I was never a fluent one. Above all, I had gained the sense of making a *thing* as distinct from doing a job, though the things which I made were as yet only drawings; I did not see beyond the drawings to the work to be built.

It was nevertheless at Hendon that I designed and saw built my first structure, all 15ft span of RC slab, design painfully with extensive study of the works of Charlie Reynolds; 5½in thick with $\frac{7}{16}$in bars at 7½in centres. I was there when they pulled away the formwork from under. I announced myself as the designer and they laughed, but I did not join in the laughter for I was sure it was going to collapse. Would I have time in the confusion to get away to South America or would I be marched away to the Tower never to be seen again by my parents? (How they would grieve). In fact, it stood up bravely and to this day continues to protect from the savagery of the elements the intimate parts of the Town Hall boiler house. To that tragic sense of imminent doom there succeeded an equally violent, equally irrational, emotion of huge elation—one was God on the seventh day surveying one's handiwork and finding it good. These strong emotions are not wholly unreal; things do fall down, and if they don't, good has been wrought. They are always with the designer and there exists (though in less degree) the same sort of gulf between theory and practice as between a military manoeuvre on the training ground and the same manoeuvre under fire from foreigners.

Royal Engineers 1940–46

At the start of the war I was in a reserved occupation; I applied to my Chief for permission to join up which he very decently granted. Why did I do it? Because an old friend of Northampton Poly days had done just that and he told me the drill. I was summoned to the Universities Recruiting Board a few days after I had injured my knee playing Rugby; the MO told me to go away and come back when the swelling had died down which I did and was passed A1.

They kept me waiting nine months and then in June 1940 off to Newark. Again the painful cultural shock. At Coventry I was earning £360 pa, a huge sum then for a boy of twenty-three (I have been, indeed now am, richer but I have never felt so rich) and I was sharing a modish flat with two architects; beautiful girls would drop in from time to time and cook us a meal. On arrival at Newark we were formed up for tea. Where were the pretty cups and saucers, the cutlery, the napery? Where the toasted teacakes and butter? A mess tin of near tea, a cube of bread, chunks of "marg" and alleged salmon consumed seated on a slag heap. And the troops! These chaste pages are no place for the shattering revelations of other vocabularies and styles of life which ensued in the next few days; suffice it to say that I developed protective colouring so effective that my nameing as an OCTU candidate was greeted by general disbelief and a little resentment—I was one of the lads was I not?

Every job I had done in civvy street (as I now called it) had started with digging a hole in the ground; what a revelation to wield pick and shovel oneself! In the confusion of night digging exercises, of course, there were ways of avoiding excessive labour; we had a miner in the section who dug his hole very rapidly and, against some small financial consideration, about a dozen of us were able to return to camp after measurement by the QMSI of the same first task.

Those of us of the middle class who had grown up in the thirties were haunted by a mystical worship of the working man; that worship did not survive six months in the ranks but was replaced by something more realistic; perhaps it was no more than fellow feeling, but the troops were no longer them but us. This was gain; so too was the sense of what a man can lift and carry and how far, all the physical realities of getting things done. Other things learnt in the ranks needed unlearning; the attitude

of scrounging and column dodging could not exist alongside the unbounded responsibilities of the commissioned officer—but even there, not all was loss. Later, when I was a section officer in a Field Company, some complicated sequence of blunders on my part led to a problem which could be resolved only by my section appearing on parade in full marching order complete with large pack and blankets. Improperly dressed with a vengeance; the rest of the company was in denims. I passed it off as a test of my section's readiness and earned golden opinions from my OC for initiative. An officer with a nicer conscience would have told the truth; would he thereby have been a better officer? I am not sure.

What an exhilaration to be posted after OCTU to a Field Company and to be given a section! Some sixty odd men complete with cooks, tools, compressor and all on wheels; we could go anywhere and do anything—and often did. In Local Government one only reached the job after ploughing through masses of paper; this was the direct approach—go and do it, and if you mess it up, heaven help you. I established a reputation; there are those who are slow but sure, and I was the contrary. I could get my section moving fast, and as the months went by it became less necessary to send back a DR for some minor but essential element of stores unaccountably missing on arrival—as it might be the detonators. Training was our main concern; at first it was a burden to dream up new stunts every day, but one warmed to the task. We had immense fun building improvised bridges (one was described by my OC in the *RE Journal* for December, 1942) out of a few hundred unserviceable bridging chesses, including a suspension footbridge of 180ft span over the River Parrett at Bridgwater. During its erection, the cordage (which was real junk) started parting. I was in despair. For two pins I would have abandoned the job—I could see someone getting hurt; but the men had the bit between the teeth, politely shouldered me aside and finished it off successfully with little help from me. Another lesson.

Did I have a nickname, or did those occasional overheard mentions of a character called "Happy Harris" refer to someone else? It came to an end when, thirsting for action, I volunteered to be a parachutist. I should not have done it; my Rugby knee was not up to it, I was medically downgraded and henceforth not fit for a Field Company. The company mobilized for North Africa soon after and I found myself back in 7 TBRE, now in Chatham.

Photo 1. 32ft span truss bridge made up from chesses.

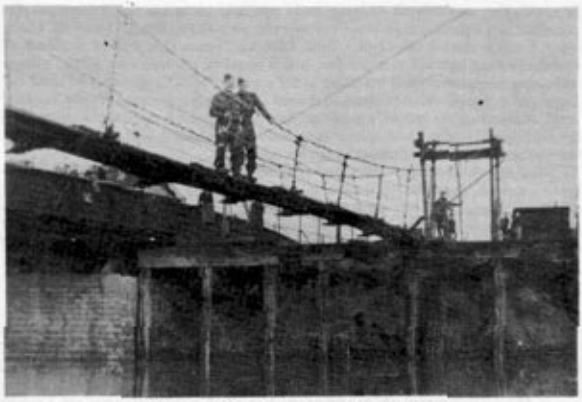

Photo 2. 180ft span footbridge at Bridgwater.

My fortunes were at a low ebb (I suffered the ignominy of having to lecture recruits on the attractions of parachuting) until an old pal passed me the tip to volunteer for Port Construction. Soon after I arrived at my new unit, the OC, in a wheedling voice, asked me if I would like to go on a diving course. Where? Why, at Chatham. Now, life had been good at Chatham; I was *persona grata* in the WRNS mess and great friends with the VADs; how nice to see them all again. So I became a diver. Back in the unit, the OC said (a different tone of voice this time, rather abrupt) "There is a course going on underwater bomb disposal, you are the diving officer, you are going." So that's what I had bought. Not that it was without attractions for certain temperaments—no wounded.

The one thing I look back on with real pride is training that Company in clearing *mines and booby traps. This, it seemed to me, was how they were most likely to be* killed; in fact despite a lot of clearance work both above and below water, we lost no one in this way except our greatly regretted CRE and his 2IC who had perhaps become too used to supervising exercises where senior officers are mine-proof.

We made a game out of it; troops going out on works would find the site mined, officers and sergeants coming back late would have to sweep their way to bed through booby traps. The 2IC, having studied the habits of the OC, armed the WC with a thunderflash, but the associations of the place proved too strong for him—and never was engineer more neatly hoist on his own petard.

There was a marked difference between a Field Company and a Port Construction and Repair Company. The latter was officered by Victoria Street in uniform; the men were mostly heavy civil engineering tradesmen and the WOIs (we had 6 WOI's in a company) works foremen. Confronted with a Bailey Bridge panel, field sappers are so conditioned that they pick it up and run away with it somewhere, the PC & R man looks at it, applies foot-rule and plumb-bob, makes a chalk mark on it, sucks his teeth and looks around for a crane. But for such things as heavy timbering they were superb.

No one knows anything about the Normandy landings unless he knows of the *exaltation of those first days, so long-awaited, so long -prepared for. It was* not that we were on the side of Justice, we were Justice, armed with care; nothing would

ever have been hit the way we meant to hit the crust on the other side. As we swung to the hook in the Solent, we saw landing craft making for the open sea with men in green berets lounging on deck; a tremor ran through the ship leaving everything slightly more taut.

We got ashore at Port en Bessin on D + 1 and were busy assisting the POL landing arrangements. (There was this concrete mixer I found on a recce; "Whose is that?" I said. "C'est à vous, Capitaine; prise de guerre!" Spoils of War! An intoxicating moment!) We then moved to Courseulles (where some of our installations are still in use) and soon after I was sent to Arromanches as OIC diving where I had a dozen teams of divers (mixed RE, RN and RM with a conspicuous pair of civilian divers from Portsmouth dockyard who had thumbed a lift over—they intended not to miss the party) engaged on "winterizing" Mulberry (some said it had not yet been summerized"). That immense undertaking, prefiguring on a smaller scale so much that is now happening in the North Sea, has not yet really had justice done to it, nor is this the place to attempt to do so. I will none the less raise the heretical question "Was it worth it?" The few small ports had a bigger capacity than expected (we were never allowed to achieve full capacity at Port en Bessin except just after the storm) and the only time when the beaches were out of action was in strong onshore winds, which in fact was during only a few days in the critical two months. Say containers had been developed to carry vital stores and jettisoned to drift ashore during those few days? The one undisputed advantage of Mulberry was, of course, the shelter it afforded for a vast fleet of small craft which would otherwise have been obliged to put to sea.

After the Falaise battle we sent my fitter sergeant with burning gear, the mobile crane and the 10T Mack to the battle field and he returned with a few dozen German rear axles on which we mounted the Company's heavy plant (welding sets etc) which could not be carried on our own transport, so that the next time we moved we towed them and needed no help from the RASC. What a lot of trouble we got into when Ordnance found out! I never understood why.

From then on the pattern was to move to the next job closely behind the advance. Sometimes we were ahead of it, but this was regarded as a mistake. There we would stay until the ethos and discipline of the battle zone changed subtly and that of the L of C was fully established, when it was high time to be off again.

Photo 3. Semi-permanent bridge at Xanten under construction. Far pile rig in operation, near pile rig being dismantled into a barge.

Our last move was under a ceiling of Liberators towing gliders to the banks of the Rhine at Xanten where we set to work building a semi-permanent bridge with timber piles built out in cantilever from each bank, the bridge super-structure being erected at the tail of the bridge over dry land and the whole thing rolled forward a span at a time—quite a novel method and one which has lately been adopted in France and Germany for big PSC spans. We were greatly helped in pitching those 90ft timber piles in a six knot current by a landing craft which we had dragged across country from Ostend, complete with Naval Officer and crew. It sounds unlikely but this exploit, unusual for HM ships, was, as I remember it, set up at Company level.

On this bridge, I had a vision. Standing on top of the pile rig, I saw the lines of the bridge emerging from the muck and chaos of the site and thrusting out over the racing waters—rectilinear, frail, adequate, the work of human hands—and was glad to be an engineer.

Then the end of the war and the Control Commission, opening up the Dortmund–Ems Canal. Suddenly there was a future.

I had shambled through my six years stint without particular glory or particular shame. I had had the wind up often, but had never been put to the final test. Thank God. I had developed a keen practical sense but was abysmally ignorant. (I remember one impassioned and slightly drunken argument in the mess as to which had the larger modulus of elasticity, concrete or steel. It is a shaming memory for the Professor of Concrete Structures that he backed the wrong horse.) Like most of my contemporaries I had started with the mentality of the old sweat, the skiver and by the end of the war I had gained a real respect for the profession of arms. I had gained no marketable advantage, but not for a King's ransom would I have missed a moment of it.

Later, when working in Paris, I was sent on a mission to the USA with two Frenchmen, Count de Lubersac, the banker, and Etève, both just out of Buchenwald. Etève, an air force ace in the first world war, a resistance leader in the second, passing his day in a frenzy of shouting and cursing, living the wildest of lives, of an intensity of patriotism seeming somewhat hectic to an Englishman, inspiring affection in all who know him, a prince amongst engineers—Etève did not at first take kindly to me, seeing in me, I suspect, something of the scoutmaster, if not the monk. Later he was to say "I often wonder why you and I get on so well together, Harris; I think it is because we are both soldiers." Nobody has ever told me anything nicer. Chaps anyhow.

Paris 1946–49

When my old firm offered me a £20 pa rise to go back (they had not made up my salary during the war) I gave Local Government the soldiers farewell, knocked on the door of Freyssinet's firm and bullied them into taking me on. It was partly the attraction of the new technique of prestressing which he had invented and of which I had heard in Ghent from Professor Magnel (a round dozen of the leading pioneers of prestressing in the UK were demobbed RE officers and most of them were from PC & R), partly the attraction of things French which had intrigued me ever since I first read Racine. Also, during my night school days I had become a Catholic and wished to live a while in a country where that condition is not seen as bizarre.

I found I had an uncovenanted advantage with Freyssinet. His forebears were peasants in the remote Limousin. He had been to the Ecole Polytechnique and had served in the Ponts et Chaussées; as such he was of the establishment—and was in revolt against it. It pleased him to oppose against the formal and mathematical approach of French official engineering, which he found frustrating, a somewhat idealized picture of British engineering; since his grandmother had lived in a house called "La Maison des Anglais", he even saw himself as a descendant of a deserter of the armies of the Black Prince. "The genius of British engineering", he told me (I did not know there was one) "is the direct intuition of physical reality." To illustrate his point, he told me of a length of canal newly liberated in Flanders in 1918. The

French set to work with level, staff and sounding rod and produced cross-sections and profiles to estimate the capacity of the length in their zone. In the British zone, a crafty sapper officer made a train of barges of increasing draught and towed it down the canal. When a barge touched it was cast off; the biggest barge to get through gave the capacity.

He looked to me to perform in similar style.

He was an inspiration. He was rough with his engineers—I don't think he really liked them. The men he did like were a few first-class foremen of works who had been with him most of his career and whom he cherished. For many years he had been a contractor/designer—a function distinct from the modern package dealer and to be seen rather as a designer executing his own designs by direct labour. In that function, his site men were invaluable.

This made his first reputation—that of an inspired builder of works in reinforced concrete (one such, the steelworks at La Colombelle, Caen, we destroyed in June 1944). He then left the firm he had created and devoted his personal fortune to developing prestressed concrete. He lost it. In a desperate gambler's throw he undertook in 1934, with borrowed money, the stabilization of the Gare Maritime at Le Havre then sliding remorselessly (and fast) into the harbour, using his own novel prestressing methods. He succeeded, and a large contractor then took him over and backed his ideas. This made his second reputation—that of inventor of new engineering techniques. Though of far more significance to engineering and, indeed, to humanity, this second reputation was slightly less respectable, tainted as it was with ironmongery and commerce; moreover for the rest of his career there was something of the captive king about him.

He was one of the great engineers. He was also the complete engineer, equally master of the concept, its development, its analysis, its pricing and of the techniques of its execution. One did not learn good design from him, one caught the infection (perhaps there is a case for the laying on of hands). Civil engineering is an art; its exercise needs much knowledge which can well be taught in academies but the art can be learnt only in practice. This was the point of articled pupilage. Every young engineer should work with a master—if he can find one, and if he can get close enough to him.

Freyssinet was above all the man of art, subjecting everything to the perfection of the finished work. Prestressing he saw as a practical process and all his engineers had to learn prestressing on site. Thus I spent a month or so at Le Havre as a member of a stressing gang as well as several months building bridges in the French Alps. I also made my name by a month's diving in the dockyard at Brest; an engineer diver was a concept novel to the French.

I would probably be in France now were it not that over there if you have not been to one of the Grandes Ecoles, you will never be "one of us", much as in politics in England, where it helps to have been to Eton—and if you have not, it is idle to produce a certificate of equivalent education. I saw my ceiling as the man who takes distinguished English-speaking visitors out to dinner and a night club; I would never be a master.

After two protracted missions to the USA, I think it was intended that I should become the Freyssinet man over there, but it did not appeal to me. I came back to England to push prestressing along over here and see what fortune would bring.

I had served my time.

* * *

Correspondence

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ROLLERS

Sir,—I believe the only catch in Mark Henniker's rollers is the fact that they are so much more difficult to make than round ones that they are not worth bothering about—except when Nature provides one accidentally in the shape of a tree that has happened to grow that way.

A former CIE&M at Ripon hereby draws the attention of the former CIF at Chatham to the 50p piece. This is a Honker roller, necessarily so if it is to work in a slot machine.

I have a book, *Further Mathematical Diversion* by Martin Gardner, published by George Allen-Unwin which touches on this topic (Chap 18). Here it is shown that constant width rollers are not necessarily based on regular polygons or even made up of circular arcs. There are also 3-dimensional constant-width objects other than spheres.

Cognate matters are the triangular drill that makes square holes, the Wankel engine and sundry pumps based on the same notion.—Yours faithfully, W H Waring.

Brigadier H W L Browne OBE MA MICE
Chief Engineer
Headquarters United Kingdom Land Forces
Salisbury
Wilts

PAST TO PRESENT

Sir,—Brigadier Begbie's article "Past to Present" is perhaps one of the most significant to appear in the *Journal* recently, concentrating as it does on the perennial question of the balance required in the Corps between combat and professional engineering.

Having like him had an upside-down career with theoretical education following instead of preceding practice—though the practice was shorter and less sharp than his—I find it easy to examine the same ground as he does, and happily reach the same conclusions. He makes the case well that, in the light of past experience, we need a healthy proportion of professionally trained officers backed up by sappers well versed in artisan skills on the establishment of all combat engineer units. Furthermore I agree with him that we are taking the most sensible steps that we can to achieve this as today's circumstances allow. My reason for writing is to enlarge on the points he makes concerning the use of field squadrons (construction), one of which will be in each of the four restructured UK engineer regiments. There are those that think that "construction" squadrons will be given the lion's share of peace-time project tasks. A glance at the draft programme in front of me which stretches into 1979 shows that this will not and indeed, because of the many constraints imposed by other factors, cannot necessarily be so, however much we might wish it.

As it happens this need not be to our disadvantage. By sharing the projects to be done amongst all field squadrons, the desired experience in "works" engineering will be automatically spread throughout officers and men without the need to cross-post. Moreover there will be less chance of an undesirable division being created between combat and professional elements in the regiment. Furthermore a normal field squadron by virtue of its establishment is more appropriate to many project tasks, especially those involving vertical engineering, than the field squadron (construction) whose establishment is plant heavy and therefore more suited to horizontal engineering. It could thus be that a field squadron would be chosen for a particular project in preference to a "construction" squadron.

One of the advantages which will stem from this sharing of that part of the construction capability which up to now has been concentrated in the one regiment (39 Engineer Regiment (Airfields)) is that in future all four UK engineer regiments can be tasked with a wider variety of projects. It also means that their COs will have much more flexibility in selecting the best sub unit and equipment to deploy on each from within their own resources.

Despite the belief that we are pointed in the right direction there is no cause for complacency. Engineer regiments in BAOR find that there is barely sufficient time in which to learn and exercise their combat skills; and certainly they find that there is little time left over for project work. In BAOR it is essential that combat readiness is unquestioned. In UK the balance between doing project work (including so-called "project exercises"), the multitude of "assistance tasks" and leaving sufficient time for combat training is a delicate one. There are those who would counsel severely cutting the project programme. The significance of Brigadier Begbie's article is the emphasis it places on the importance of an all-round engineer capability to the combat engineer in 1939–45. The next war and its aftermath will be very different, but we would be most unwise to assume that the demands placed on engineer units will be less varied.—Yours faithfully, H W L Browne.

Memoirs

BRIGADIER A G H BROUSSON, OBE, MA, C Eng, MI Mech E

Born 22 April 1907, died 24 May 1976, aged 69

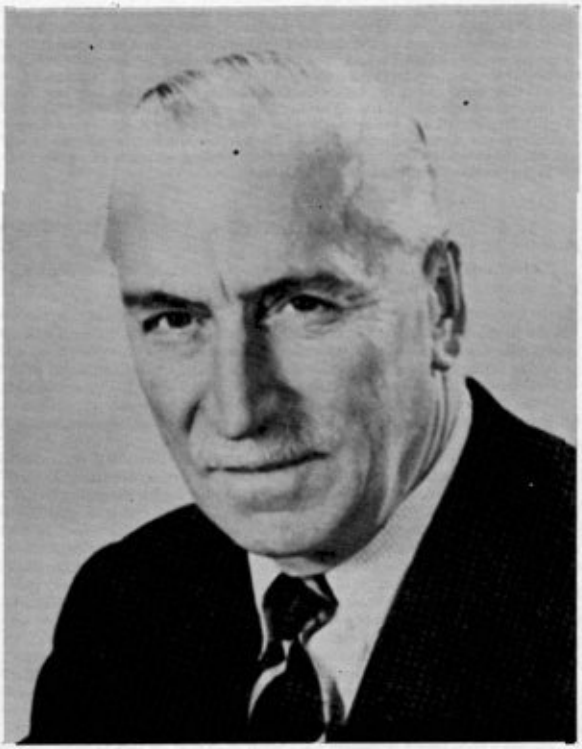
TONY BROUSSON, a man of many talents and accomplishments would have made a success in any chosen field, but as an experienced civil, mechanical and military engineer he was fortunate in his generation that he was able to complete a full and satisfying career to senior rank within the Corps before the civilianization of the Works Services. CRE Northern Ireland District, CRE British Element Trieste, CE West Africa and CE Cyprus, to name only some of his senior appointments, all gave scope for the exercise of his abilities in control of all engineer resources under him.

He was educated at Westminster and RMA, commissioned in 1927 and took his degree at St Catherine's College, Cambridge. Early years of service from 1935 were spent in the Sudan, mostly as GE attached to the PWD. On the outbreak of war he rejoined the Engineer Troops of the Sudan Defence Force and took part in the Eritrean campaign and subsequently in the Western Desert, for which he was awarded the OBE in 1944. A lifelong friend who knew him from those days writes: "As a man, Tony was a most likeable character, a brilliant mathematician which showed in his playing of bridge, of which he was passionately fond and very good. He was an enthusiast either in his work or hobbies such as model making. He had a unique gift of teaching, whether young Sudanese apprentices who loved him or with anyone else. I don't think I have ever heard him say a bitter word about anyone."

In Northern Italy in 1951, in severe winter weather, the valley of the River Po was inundated by devastating floods. Brousson was sent from Trieste to take charge of a mixed British force in the rescue and repair operations under Italian command. It was a unique and very arduous task, which he executed with great initiative and cheerful determination and for which he received a well deserved Italian decoration.

He was a good choice to become CE Cyprus in 1956 at the time of Suez, the rise of the terrorist EOKA campaign, and emergency in Jordan: with the consequent many crash programmes of camp construction for troops reinforcements superimposed on an already heavy permanent cantonment building programme. Whatever the emergency he always appeared relaxed, unhurried yet decisive, his desk as often as not covered with mathematical doodles, the twinkle of good humour rarely absent and the flash of interest at some new engineering problem to be solved ever ready to appear. He was a shy man in many ways and gentle, preferring off duty the intimacy of his own home and circle to official and social engagements.

Brousson's last job as DDW BAOR did not really suit him. The civilianization of the Works Services was something he deeply deplored and his sudden uprooting from the active job that he enjoyed in Cyprus to the somewhat artificial atmosphere of HQ BAOR was not to his liking. So he retired early, and went to do what he had long had in mind, to teach maths. He started as Assistant Lecturer at Braintree College in 1959 and ten years later had risen to be head of the Science Department



until his final retirement in 1973. The Principal of the College wrote of him in the local press: "As a member of staff he was greatly loved by his colleagues and by students who regarded him as a very friendly father figure. He was an outstanding teacher who would enjoy teasing and puzzling his students and not only his students but also by correspondence in the learned journals to which he contributed. These and his Brain-teasers in the *Sunday Times* proved again and again that he possessed a brilliant, incisive but humorous mind."

Our deep sympathy goes to his wife Lorna, devoted and constant companion for over forty years, and to his son Clive who, to his great satisfaction, also started his career in the Corps.

APL

* * *

Brigadier A G H Brousson OBE MA C

MAJOR M D A CLINTON CMG, GM*, JP

MICHAEL DENYS ARTHUR CLINTON served in the Royal Engineers 1939–1946. He was one of the few to be twice awarded the George Medal for gallantry in Bomb Disposal. In a strange way it was his work in Hong Kong, where he served in the Public Services for thirty years, which gave him the most satisfaction.

Of his Bomb Disposal work he said "It really wasn't anything very much. Just the sort of thing a lot of people did, I was rather lucky, that's all' (El 17A's and ZUS 50's!!)

In 1946 he went to Hong Kong to join the Military Administration, "he found a ruined city, ravaged by shell fire, bombs and looting—its hillsides despoiled, the fields abandoned, the port a graveyard of broken ships, the population reduced to half a million—the legacies of a nightmare which had lasted for nearly four years". He served mainly in Central Government, largely concerned with economic and financial affairs. For the last six years of his service he was Deputy Colonial Secretary. In the thirty years Hong Kong was "transformed into a trading, financial and banking centre of international importance, a vibrant, vigorous and crowded city.... Michael was one of the select band which gave the leadership and to him and them must go a generous measure of credit for the part the public service has played in the amazing development". These extracts are from the Eulogy delivered by the Colonial Secretary, Sir Denys Roberts, KBE, QC, JP, at the Requiem Mass in Hong Kong.

He left Hong Kong in November 1975, he had been seriously ill for some time and he died on 31 May 1976 at his home in Dorset, aged 57.

Book Reviews

THE WORKS OF ISAMBARD KINGDOM BRUNEL

EDITED BY SIR ALFRED PUGSLEY

(Published by Institution of Civil Engineers and University of Bristol. Price UK £6·50)

MUCH has been written before about Isambard Kingdom Brunel, indeed he appears in the titles of seven of the references in this new book, and many more are about his works, so what is new or different about this book?

Brunel excites our interest and admiration because he was a pioneer in many fields of engineering at the same time. This is the key to the book. Seven eminent engineers, each a modern specialist in one field, have contributed seven chapters on Tunnels, Clifton Suspension Bridge, Railways, Arch Bridges, Timber Works, The Three Great Ships, and The Royal Albert Bridge, Saltash, analysing not only how he was successfully ahead of his time in many respects, but also some of his mistakes and failures. Add to these an opening chapter on how he ran his business, and a closing chapter on some of his theoretical and experimental work, and you have a graphic picture of the man and his works written by and for engineers. Three sources of original material—the collection of Brunel's papers in the Library of the University of Bristol, others still in the possession of the family, and engineering drawings still held by British Rail—were used, and many of the illustrations in the book are copies of some of Brunel's original work.

The book is easy to read, and the difficulties inherent in bringing the work of several authors together on a single subject have been well handled. Inevitably there are a few minor cases of duplication, but the balance between the various sections is on the whole good. A few extra illustrations might have improved the whole, particularly a map, because so much of his work was connected with the development of railways and only railway enthusiasts are likely to know the original names of the many parts of our railway system. The remarkable thing about the book is that so much material has been condensed into less than 200 pages of text and illustrations that one is left longing to know more about the subject of each chapter.

For any engineer who is interested in Brunel and his works but who has been unable to find time to satisfy this interest this book is a must.

DET-R

AS CHINA FELL

DOROTHY JACOBS-LARKOM

(Published by D Jacobs-Larkom. Price £3·50)

WHEN asked to review *As China Fell* I thought to myself—I am not doing anything for a few days (the rain was keeping me out of the garden) and it will be a nice change. After 157 pages of sheer fascination, I re-read the book (the weather improved but the garden had to wait) and my admiration of the authoress increased. Not because she was a "Sapper wife" whose husband had joined the Foreign Service but because she made her experiences come to life. With her husband and their two little girls she spent 1946–49 in North China at a time when the Nationalists and Communists were "locked in combat". It must have been alarming as cities could change hands in twenty-four hours. She recounts the most amazing incidents with humour, and one cannot avoid identification or help feeling involved.

Mrs Jacobs-Larkom takes hazardous journeys in her stride and accepts upheaval as a normal way of life. Often she had to leave behind precious possessions, sometimes her husband. She coped with the duties of a Consul's wife, was both mother and nurse to their daughters, dealt with an ever changing domestic staff, was prepared to pack and move at a minute's notice and rebuild a new home just as quickly. A truly remarkable lady all the more so because of her ability to describe it all so vividly.

I felt afterwards that the moves I had made as a Service wife were, in retrospect, too easy for words. The problems I had faced wouldn't have made Mrs Jacobs-Larkom even blink. It brought home to me how things have changed, how one no longer has to think—so much more is now done for the wives.

My one criticism of the book is that it should have included a good map showing the places referred to in the text. Using my own atlas, with the spelling of place names on a somewhat different basis, was confusing at times.

This book brought me enormous pleasure but I would like to emphasize that it is not just a woman's book, although I think that wives will enjoy it more than husbands (it should be made compulsory reading for husbands—wives have problems too!). I do recommend it as an additional Christmas present. As your reviewer does not get a free copy it is already high on my Christmas list for my husband!

BP

WORLD UNIFORMS AND BATTLES 1815–1850

PHILIP HAYTHORNTHWAITE

(Published by Blandford Press. Price £2·75)

PHILIP HAYTHORNTHWAITE, aided by Michael Chappell's detailed and colourful illustration, has covered not only 136 uniforms from twenty-seven armies, but also the military history of thirty-six years from the Battle of Waterloo.

This is a remarkable achievement in a slim book containing five black and white and sixty-four colour plates with 113 pages of text. It is in trying to cover so much in so little space, that this book fails to attain the publishers aim to "be of interest to the historian and uniform enthusiast" and "a fund of information for the model maker and wargamer". A book of this kind is, by its very nature, more a reference book than one for general reading and for all four types of enthusiast, source references are essential. A few are given, but all too few. The author states that there is "insufficient space to enumerate the many (often conflicting) sources", yet it is the conflict that makes it essential to quote the sources used. Space could so easily have been made by omitting items such as the lengthy paragraph on the desire to look up Highlanders' kilts, shared by Parisian ladies(!) and the Czar of Russia, which have presumably been included to make the book of general interest.

The book is well laid out in related sections. The historical background is detailed yet concise and Philip Haythornthwaite obviously has an extensive knowledge of uniforms. In addition to specific uniform details, he points out the similarities between armies due to copying of fashions and the effect of republican influence on dress in general. It is a pity that, no doubt for economic reasons, he aimed to cover too many aspects in too small a book.

JTH

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